Operating Instructions

HAEFELY TEST AG

2830/2831

Precision Oil and Solid Dielectric Analyzer

Version 2.0

4843477

Date	Version	Author	Remarks
Dez 2013	2.0	MB	2nd Version

Foreword

Welcome as a new user of the “Precision Oil and Solid Dielectric Analyzer 2830/2831”.Thank you for placing your confidence in our product.

With the purchase of this measuring instrument you have opted for all the advantages that have built a world-wide reputation for a Tettex Instrument: Robustness, performance and quality is assured. As a result this instrument provides a solution which achieves the optimal combination of traditional know-how and leading edge technology.

Any correspondence regarding this instrument should include the exact type number, instrument serial number and firmware version number. With the exception of the firmware version number, this information can be found on the registration plate on the rear panel of the instrument. The firmware version specified in the “About” menu.

The design of this instrument will be continuously reviewed and improved where possible. Therefore there may be small differences between the operating manual and the actual instrument. Although all efforts are made to avoid mistakes, no responsibility is accepted by HAEFELY TEST AG for the accuracy of this operating manual.

This operating manual is designed for completeness and easy location of the required information. Customers who already have experience with this kind of equipment will find this document to be of assistance as an extended help. A keyword index at the end of the operating manual greatly eases use.

If you find a mistake or inconsistency in the operating manual then please feel free to inform our Customer Support department with your corrections so that other users may benefit.

HAEFELY TEST AG accepts no responsibility for any damage that may be caused during use of this document. We reserve the right to amend the operation, functionality and design of this instrument without prior notice. If discrepancies are noticed between the on-line help provided by the instrument and the operating manual, then the on-line help should be followed.

Contents

1 Safety

1.1 General

In general a high voltage measuring system is a large danger source for accidents. Thus must be observe the following notes and safety regulation. **Installation and operating personnel must know the procedures following a high voltage accident.**

Remember - Hazardous voltage can shock, burn or cause death !

This warning sign is visible on the equipment.

Meaning:

This unit should only be operated after carefully reading the user manual which is an integral part of the instrument.

Haefely Test AG and its sales partners refuse to accept any responsibility for consequential or direct damage to persons and/or goods to none observance of instructions contained herein or du incorrect use of the system

Further be aware that safety is the responsibility of the user !

Do not switch on or operate the system if an explosion hazard exist. The system should be operated in a dry condition. If condensation is visible, the affect system should be dried before operating.

The system should only be operated by trained personnel.

If the system or any parts of the system are damaged or it is possible that damages has occurred, for example during transportation, do not apply any voltage.

Dangerous mains voltage or high voltage are present inside the system and all modules attached to it.

The protective earth must be connected to earth and all modules must be connected on the mainframe using earth studs.

Do not open the system , they contains no user replaceable parts.

Before changing the main fuse, remove the main power cord.

Fuses should only be replaced with the same type and value

1.2 Additional System Safety

The high voltage can only be switched on if all safety requirements are fulfilled. Thus no safety devices of the system are to be bridged.

The safety interlock is not to be shorted under any circumstances.
The safety interlock should only be opened after the high voltage has been switched off.

All emergency off switches must always be accessible.

Don’t disconnect any cables from the System 2830/2831, the oil test cell 2903 or the solid test cell 2914 when using High Voltage.

Use heating tested gloves and protective goggles, when you manipulate on the oil test cell 2903 or solid test cell 2914. The test cells can be over 200 °C hot.

Use the solid test cell 2914 only with the protective cover.

1.3 Summary

Note: **Many accidents that happen around high voltage equipment involve personnel who are familiar, and perhaps too familiar, with high voltage equipment.**

Staying alert and ever watchful requires constant training and awareness of the inherent hazards. The greatest hazard is the possibility of getting on a live circuit. To avoid this requires constant vigilance - for oneself and for one's fellow workers.

Personnel whose working responsibilities involve testing and maintenance of the various types of high voltage equipment must have understood the safety rules written in this document and the associated safety practices specified by their company and government. Local and state safety procedures should also be consulted. Company and government regulations take precedence over Tettex recommendations.

Safety is the most important aspect when working on or around high voltage electrical equipment.

Remember - Safety, FIRST, LAST, ALWAYS !

2 Introduction

2.1 Receiving Instructions

When taking delivery, any possible transport damage should be noted. A written record should be made of any such damage. A suitable remark should be recorded on the delivery documents.

A claim for damage must be reported immediately to the transport company and to the Customer Support Department of HAEFELY TEST AG or the local agent. It is essential to retain the damaged packing material until the claim has been settled.

Check the contents of the shipment for completeness immediately after receipt (See chapter “Scope of Supply”). If the shipment is incomplete or damaged then this must be reported immediately to the transport company and the Customer Support Department of HAEFELY TEST AG or the local agent. Repair or replacement of the instrument can then be organised immediately.

2.2 General

The Precision Oil and Solid Dielectric Analyzing System is designed for measurement of liquid and solid insulating materials with a very low dielectric losses (Dissipation Factor and Power Factor) of high-voltage insulating material (e.g. Transformer Oil).

The instrument works on the principle of a combined bridge-vector-meter and is capable of analyzing capacitive and dissipation factor (tan δ) as well as DC-Resistivity with outstanding accuracy and stability.

The Graphical User Interface of the instrument is highly intuitive, focussed on convenience with built-in useful programs (e.g. pre-programmed procedures according the standards) and uses a large colour touch screen as the input device. The operator can choose between manual or automatic modes. While the manual mode provides quick measurements, the automatic test mode supports complete automated test sequences according the standards.

2.3 Hardware

This high precision measuring instrument (double vector meter) is fully automatically balanced by the built-in PC and the measurement values are calculated and displayed. 13 various parameters can be measured respectively calculated. The instrument, as a vector meter bridge including the heating regulation, DC and AC power supply, DC resistance measurement.

2.4 Software

Advanced software functionalities such as pre-programmed test sequences according standards and graphical visualization of measured data, etc. make this instrument a powerful tool for analysis of high-voltage insulating material. The clear structured user interface makes the settings and the sequence programming fast and easy.

2.5 Scope of Supply

The standard scope of supply includes the following items:

Qty	Description
1	Precision Oil and Solid Analyzer 2830/2831
1	Inter-Wiring cable set
2	Mains cable 10A and 16A (country specific)
1	Operating instruction
1	Test certificate
	Test cables corresponding to order

2.6 Optional Accessories

For details on optional accessories (Oil Test Cell 2903 and Solid Test Cell 2914) and test cable sets see product brochure and/or contact the Tettex Sales.

Note: If you use existing oil test cells 2903 or solid test cells 2914 with the 2830/2831 you need a new measuring cable set

Order Information:

4842611 cable set for existing 2903A and 2903H
4842507 cable set for existing 2914

2.7 Abbreviation and Definitions

Wherever possible the corresponding IEC or SI definitions are used. The following abbreviations and definitions are used in this manual:

SI	Système International d'unités (International System of Units)
IEC	International Electrotechnical Commission
ASTM	American Society for Testing and Materials
BS	British Standards
VDE	Verband der Elektrotechnink
SAC	Standardization Administration of China
C_N	Standard capacitor (measurement reference; built-in the 2831)
C_X	Test object capacitance (e.g. transformer oil, oil paper, solid material etc.)
HV	High voltage
$\cos\varphi$	Power factor
PF	Power factor
$\tan\delta$	Dissipation factor
DF	Dissipation factor
DUT	Device under test
ppm	Parts per million
ε_0	Vacuum Permittivity
ε_r	Relative Permittivity

3 Technical Data

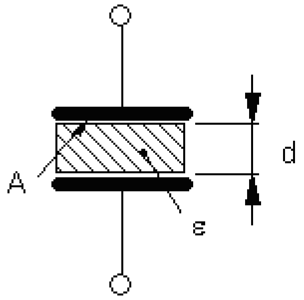
Measurement 2830	Range	Max. Resolution	Accuracy
Dissipation Factor (tan δ) 1	0 .. 100	1×10^{-5}	± 0.5 % rdg ± 1×10^{-5}
Capacitance 2	≥ 10 pF	0.001 pF	± 0.2 % rdg ± 0.01 pF
Relative Permittivity ε_r	1 .. 30	1×10^{-3}	
Resistance	120 kΩ .. 5 TΩ 3	1 kΩ	< 1 TΩ ± 5 % rdg+ 3 digits ≥ 1 TΩ ± 15 % rdg+ 3 digits
Resistivity (Liquid) 4	900 kΩm .. 27 TΩm 5		
Resistivity (Solid) 6	2.4 MΩm .. 80 TΩm 7		
Test Current @ Input Cx	10 uA .. 10 mA	0.01 uA	± 0.1 % rdg ± 0.1 uA
Test Current @ Input Cn	10 uA .. 10 mA	0.01 uA	± 0.1 % rdg ± 0.1 uA
Test Frequency	15 Hz .. 100 Hz	0.01 Hz	± 0.1 % rdg ± 0.1 Hz
Power Supply's 2831	**Range**	**Max. Resolution**	**Accuracy**
AC Test voltage	40 V .. 2.5 kV	1 V	± 0.3 % rdg ± 1 V
AC Frequency	40 Hz .. 65 Hz	0.1 Hz	
AC Current max.	5 mA		
DC Test Voltage	250 V .. 2.5 kV	25 V	+ 10 % rdg ± 20 V
Heater			
Heating Temperature	Ambient - 200°C	0.1°C	± 0.5°C
Internal Standard capacitor	**Value**		**Accuracy**
Dissipation Factor (tan δ)	1×10^{-5}		± 2×10^{-5}
Capacitance	1 nF ± 5 % @ 25 °C		20 ppm/°C
Additional Specifications			
Preprogrammed Standards	IEC 60247:2004; ASTM D924-08; ASTM D1169:2002; VDE 0380-2:2005; BS 5737:1979; SAC GBT 5654:2007		
Display	12" TFT, 800x600, integrated Touch-Screen		
Operating System	Windows Embedded 7		
Interfaces	3 x USB		
Data Format	XML, CSV		
Operating Temperature	10 .. 40 °C		
Storage Temperature	-20 .. 70 °C		
Humidity	10 .. 60 % r.h. non-condensing		
Protection classes, Standards	IP20, IEC 61010, CE mark, General IEC 61326-1, IEC 61000-4-X, 61000-3-X, EN 55011, ANSI/IEEE C37.90		
Safety Specification	VDE 0411/part 1a , IEC/EN 61010-1:2002		
Supply 2830	90 .. 264 VAC, 100 VA, 50 / 60 Hz		
Supply 2831	90 .. 264 VAC, max.1.7 kVA, 50 / 60 Hz		
Weight	21kg (2830), 19kg (2831)		
W x H x D	2 pcs 48 x 27 x 44 cm (19" x 10.6" x 17.3")		

1 Accuracy values @ 50/60Hz
2 Range limit is given by test current and voltage
3 @ 2.5 kV (Rmax = 2 GΩ x Utest [V])
4 Resistivity range is given by the resistance range multiplied with the cell factor of the test cell (2903 = 0.113 x Cair [in pF])
5 Typical range (calculated with Cair = 60.0 pF of 2903 and 2 kV test voltage)
6 Resistivity range is given by the resistance range multiplied with the ratio: surface area of the measurement electrode / distance between the HV and the measurement electrode (2914 = 0.002 m^2 / distance in m)
7 Typical range (calculated with a distance of 0.1 mm between the electrodes and 2 kV test voltage)

4 Theory

4.1 Dissipation Factor tanδ

To specify the insulation loss factor, the test object must be considered in the test arrangement as a capacitor. Consider the liquid test cell and solid test cell. Are constructed from metal and insulation, and therefore possess associated capacitive properties. Every test cell consists of two electrodes: a high voltage and a guarded measuring electrode. The capacitance of the insulating material between the two electrodes will be measured. The figure shows the components that comprise a capacitance and the diagram for a simple disc capacitor.



Disc Capacitor

$$C = \frac{\varepsilon \cdot A}{d}$$

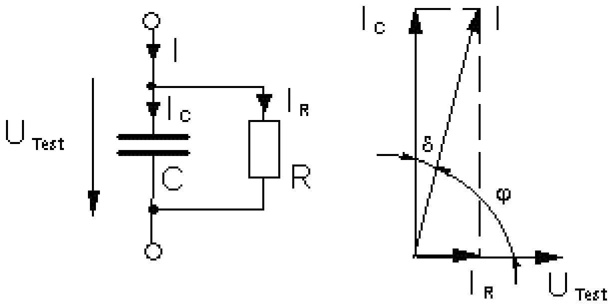
where:

A	electrode face
d	distance between the electrodes
C	capacitance
ε_0	dielectric constant of air (ε_0=8,8542•10^{-12} F/m)
ε_r	relative dielectric constant dependent upon material
ε	$\varepsilon = \varepsilon_0 \cdot \varepsilon_r$, dielectric constant

In an ideal capacitor the resistance of the insulation material (dielectric) is infinitely large. That means that, when an AC voltage is applied, the current leads the voltage by exactly 90° as it flows as pure current.

After further consideration it must be realized that every insulation material contains single free electrons that show little loss under DC conditions with $P = U^2/R$. Under AC a behaviour called dielectric hysteresis loss occurs which is analogous to hysteresis loss in iron.

As losses therefore occur in every insulation material, an equivalent diagram of a real capacitance can be constructed as follows:



Parallel equivalent diagram of a loss capacitance with vector diagram

Loss factor (Dissipation Factor)

$$\tan\delta = \frac{P}{Q} = \frac{I_R}{I_C} = \frac{X_C}{R} = \frac{1}{\omega \cdot C \cdot R}$$

Power Factor

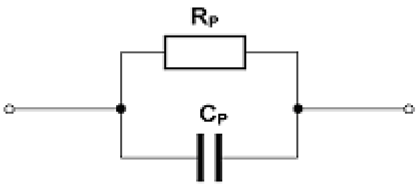
$$PF = \cos\varphi = \frac{I_R}{I} = \frac{P}{S} = \frac{\tan\delta}{\sqrt{1+\tan^2\delta}}$$

Q	Reactive Powre
S	Apparent Power
P	Real Power
U_{Test}	applied test voltage
I_C	current through capacitance
I_R	current through resistance (insulating material)
I	$I_C + I_R$
C	ideal capacitance
R	ideal resistance

Because P = Q • tan δ, the losses which are proportional to tan δ, will usually be given as a value of tan δ to express the quality of an insulation material. Therefore the angle δ is described as loss angle and tan δ as loss factor.

4.2 Parallel & Series Equivalent Circuits

The measuring bridge measures and displays both - the parallel and/or series equivalent circuit values. The following formulas describe the calculation of the value conversion parallel – series :

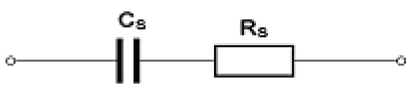


Parallel equivalent circuit

Parallel Equivalent Circuit C_p-R_p

$$Rp = \frac{1}{\omega \cdot \tan\delta * \cdot Cp *}$$

* measured values



Series equivalent circuit

Series Equivalent Circuit C_s-R_s

$$Cs = Cp * \cdot (1 + \tan^2\delta *)$$

$$Rs = Rp \cdot \frac{\tan^2\delta *}{1+\tan^2\delta *}$$

* measured values

4.3 The Difference between Power Factor and Dissipation Factor

While “Dissipation Factor” tan δ is used in Europe to describe dielectric losses, the calculation used in the United States is „Power Factor“ cos φ.

The statistical data that have been collected in North America have been calculated using the loss factor cos φ (Power Factor) to specify the power losses in the insulation. Because the angles are complimentary it is unimportant whether tan δ or cos φ is used as with very small values tan$\delta \leq$ 0.5% the difference is negligible. However the conversion formulas are:

$$PF = \frac{\tan\delta}{\sqrt{1+\tan^2\delta}} \qquad \tan\delta = \frac{PF}{\sqrt{1-PF^2}}$$

4.4 Relative Permittivity

The linear permittivity of a material is usually given relative to ε_0 the permittivity of free space (vacuum permittivity), as a relative permittivity ε_r (also called the dielectric constant). In a anisotropic material, the relative permittivity maybe a tensor, causing birefringence. The actual permittivity is then calculated by multiplying the relative permittivity by ε_0.

$$\varepsilon = \varepsilon_r \cdot \varepsilon_0$$

to solve equations to ε_r the below formula results.

$$\varepsilon_r = \frac{\varepsilon}{\varepsilon_0}$$

The permittivity of free space (vacuum permittivity) also called electric constant ε_0 is the ratio D/E in free space. It also appears in the Coulomb force constant $1/4\pi\varepsilon_0$.

D = electric displacement field
E = electric field
ε_0 = vacuum permittivity
c_0 = speed of light
μ_0 = vacuum permeability

The constants c_0 and μ_0 also called “physical constants” are defined SI units to have exact numerical values.

$$c_0 = 2.99792458 \cdot 10^8 \frac{m}{s} \qquad \mu_0 = 4\pi \cdot 10^{-7} \frac{Vs}{Am}$$

$$\varepsilon_0 = \frac{1}{\mu_0 \cdot c_0^2} = \frac{1}{\left(4\pi \cdot 10^{-7}\frac{Vs}{Am}\right) \cdot \left(2.99792458 \cdot 10^8 \frac{m}{s}\right)^2} = 8.8541878....10^{-12}\frac{F}{m} = 8.85...\frac{pF}{m}$$

C_{oil} = Measured capacity of the test cell with liquid insulating dielectric
C_{air} = Measured capacity of the test cell with air as dielectric (Tettex Oil Test Cell 2903 approx. 60pF ±20%)
ε_0 = Vacuum permittivity
$\varepsilon_{r\,oil}$ = Relative permittivity of the liquid insulating
$\varepsilon_{r\,air}$ = Relative permittivity of air (≈ 1)
A = Surface of test cell (Tettex Test Cell 2903 approx. 0.0134m^2)
l = Distance between surface (Tettex Oil Test Cell 2903 approx. 0.002m)

The relative permittivity ε_r can be calculated according the below formula and this according the standards.

$$\varepsilon_{r_{oil}} = \frac{C_{oil}}{C_{air}}$$

$$C_{oil} = \frac{\varepsilon_0 \cdot \varepsilon_{r_{oil}} \cdot A}{l} \qquad C_{air} = \frac{\varepsilon_0 \cdot \varepsilon_{r_{air}} \cdot A}{l}$$

to solve equations to ε_r the below formula results.

For ε_r of liquid (oil)

$$\varepsilon_{r_{oil}} = \frac{C_{oil} \cdot l}{\varepsilon_0 \cdot A}$$

For ε_r of air

$$\varepsilon_{r_{air}} = \frac{C_{air} \cdot l}{\varepsilon_0 \cdot A} \approx 1$$

$$\frac{\varepsilon_{r_{oil}}}{\varepsilon_{r_{air}}} = \frac{\frac{C_{oil} \cdot l}{\varepsilon_0 \cdot A}}{\frac{C_{air} \cdot l}{\varepsilon_0 \cdot A}} = \frac{C_{oil} \cdot l}{\varepsilon_0 \cdot A} \cdot \frac{\varepsilon_0 \cdot A}{C_{air} \cdot l} = \frac{C_{oil}}{C_{air}}$$

$$with \quad \varepsilon_{r_{air}} \approx 1 \Rightarrow \quad \varepsilon_{r_{oil}} = \frac{C_{oil}}{C_{air}}$$

Dissipation Factor and Dielectric Constant of Typical Insulation Materials

Typical values of 50/60Hz dissipation factor and permittivity (dielectric constant ε_r) of some typically used insulating materials.

Material	Dissipation factor @ 20°C	ε_r
Vacuum		1.0
Acetal resin (Delrin™)	0.5%	3.7
Air	0.0%	1.00059
Askarels	0.4%	4.2
Kraft paper, dry	0.6%	2.2
Transformer oil	0.02%	2.2 … 2.4
Polyamide (Nomex™)	1.0%	2.5
Polyester film (Mylar™)	0.3%	3.0
Polyethylene	0.05%	2.3
Polyamide film (Kapton™)	0.3%	3.5
Polypropylene	0.05%	2.2
Porcelain	2.0%	6 … 8
Rubber	4.0%	3.6
Silicone liquid	0.002%	2.6
Varnished cambric, dry	1.0%	4.4
Water	100%	80
Ice	1.0% @ 0°C	88

Note: Tests for moisture should not be made at freezing temperatures because of the 100 to 1 ratio difference dissipation factor between water and ice.

4.5 DC Resistivity

The DC-Resistivity (also called electrical resistivity, resistivity, specific electrical resistance or volume resistivity) is a measure of strongly a material opposes the flow of electric current. A low resistivity indicate a material that readily allows the movement of electric charge. The SI unit of the dc resistivity is the ohm-meter (Ωm). It is commonly represented by the Greek letter ρ (rho).

The measurement of dc resistivity of liquids depends on a number of test condition:

a. Temperature

Resistivity is very sensitive to changes of temperature, its dependence on the inverse of the temperature, expressed in Kelvin,(1/K) is generally exponential. It is therefore necessary to carry out measurements under sufficiently precise temperature condition.

b. Electrical stress

The resistivity of a given specimen my be influenced by the applied stress. For results to be comparable, measurement shall be made with approximately the same electrical stress and polarity.

c. Time of electrification

Upon the application of DC voltage, the current flow through the specimen decrease due to the sweep of charge carriers to the electrodes. The conventional arbitrary time of electrification is 1 min. Variation in the time of electrification can result in appreciable variation in the results. (Some high viscosity fluids may required considerably longer electrification time).

Calculation of the resistivity in ohmmeters by means of:

Liquid Test Cell 2903

$$\rho[\Omega m] = K \cdot \frac{U}{I}$$

Solid Test Cell 2914

$$\rho[\Omega m] = \frac{A}{l} \cdot \frac{U}{I}$$

U	DC test voltage
I	DC test current
K	Liquid cell constant in meters
C_{air}	Measured capacity in air (Tettex Test Cell 2903 approx. 60pF ±20%)
ε_0	Vacuum permittivity
ε_r	Relative permittivity of air or liquid
A	Surface of the measurement electrode (Tettex Test Cell 2903 approx. 0.0134m^2 / 2914 approx. 0.002 m^2)
l	Distance between electrodes (Tettex Test Cell 2903 approx. 0.002m / 2914 depends on sample thickness)

$$K[m] = 10^{12} \cdot \frac{1}{\varepsilon_0} \cdot C_{air}[pF] = 0.113 \cdot C_{air}[pF]$$

The cell constant can also by calculated according the following formula:

$$\frac{\varepsilon_0 \cdot \varepsilon_r \cdot A}{l} = C_{air} \qquad \frac{1}{\varepsilon_0} = 0.113 \cdot 10^{-12}$$

$$K = \frac{C_{air}}{\varepsilon_0} = \frac{\frac{\varepsilon_0 \cdot \varepsilon_r \cdot A}{l}}{\varepsilon_0} = \frac{\varepsilon_0 \cdot \varepsilon_r \cdot A}{l} \cdot \frac{1}{\varepsilon_0} = \frac{\varepsilon_r \cdot A}{l}$$

$$with \Rightarrow \varepsilon_r \approx 1 \Rightarrow K[m] = \frac{A}{l}$$

4.6 Test Instruments

There are three basic kinds of capacitance, tan δ and Power Factor test instruments in use.

Although the high accuracy Schering Bridge must be balanced manually and the balance observed on a null indicator, it has been widely sold and used for decades up until this day. The capacitance and dissipation factor can be calculated by reading the position of the balance elements.

The automatically balanced C tan δ measuring instrument performs measurement by the differential transformer method. The automatic balancing makes operation very easy.

The double vector-meter method is essentially an improvement of the differential transformer method.

All three methods are in current use for accurate and repeatable measurements of C tan δ on various test objects. The differences basically lie in the resolution and accuracy. Different instruments are generally developed specially for field or laboratory measurement.

Field instruments are specially constructed for rugged field requirements and are equipped with a mobile high voltage source. In addition, such instruments provide noise suppression for onsite use.

Laboratory instruments have been constructed for indoor use where high accuracy specifications are required. These test systems are built in a modular construction for higher Test Levels. The systems may be used for daily routine testing, for high precision long duration tests or for acceptance tests.

4.7 Evaluation of Test Results

Significance of Capacitance and Dissipation Factor and DC Resistivity

A large percentage of electrical apparatus failures are due to a deteriorated condition of the insulation. Many of these failures can be anticipated by regular application of simple tests and with timely maintenance indicated by the tests. An insulation system or apparatus should not be condemned until it has been completely isolated, cleaned, or serviced. The correct interpretation of capacitance and dissipation factor tests generally requires a knowledge of he apparatus construction and the characteristics of the types of insulating material in used.

Changes in the normal capacitance of insulation indicate such abnormal conditions as the presence of a moisture layer, short circuits, or open circuits in the capacitance network. Dissipation factor measurements indicate the following conditions in the insulation of a wide range of electrical apparatus:

- Chemical deterioration due to time and temperature, including certain eases of acute deterioration caused by local overheating.
- Contamination by water, carbon deposits, bad oil, dirt and other chemicals.
- Severe leakage through cracks and over surfaces.
- Ionization.

The interpretation of measurements is usually based on experience, recommendations of the manufacturer of the insulating materials , and by observing these differences:

- Between measurements on the same material after successive intervals of time.

An increase of dissipation factor above a typical value may indicate conditions such as those showed above: If the dissipation factor varies significantly with voltage down to some voltage below which it is substantially constant, then ionization is indicated. If this extinction voltage is below the operating level, then ionization progress in operation with consequent deterioration. Some increase of capacitance (increase in charging current) may also be observed above the extinction voltage because of the short-circuiting of numerous voids by the ionization process.

An increase of dissipation factor accompanied by a marked increase of the capacitance usually indicates excessive moisture in the insulation. Increase of dissipation factor alone may be caused by thermal deterioration or by contamination other than water.

Influence of Temperature

Most insulation measurements have to be interpreted based on the temperature of the specimen. The dielectric losses of most insulation increase with temperature. In many cases, insulations have failed due to the cumulative effect of temperature, e.g. a rise in temperature causes a rise in dielectric loss which causes a further rise in temperature, etc.

It is important to determine the dissipation factor temperature characteristics of the insulation under test, at least in a typical unit of each design of apparatus. Otherwise, all tests of the same spec should be made, as nearly as practicable, at the same temperature.

The DC resistivity is very sensitive to changes of temperature, its dependence of the inverse of the temperature, expressed in Kelvin, (1/K) is generally exponential. It is therefore necessary to carry out measurements under sufficiently precise temperature condition.

Influence of Humidity

The major electrical effect of humidity on an insulating material is to increase greatly the magnitude of its interfacial polarization, thus increasing both its permittivity and tan δ as well as the dc conductance. These effects of humidity are caused by absorption of water into the volume of the material and by the formation of an ionized water film on its surface.

Influence of electrode Surface

The surfaces of the oil test cell or the solid test cell should be clean and with out any scratch or other damaged when making measurement. Scratches and other mechanical damages increase the tan δ and in the worst case a break down can occur.

4.8 Other Test Methods

As of today there exists no other test method that can replace the currently used C & tan δ test. Nevertheless, several measurement methods exist which compliment dissipation factor measurement and assist in localization of poor quality of liquid or solid insulating materials.

Oil Analysis Measurements provide useful information about the insulating oil in transformers and oil-paper insulation systems.

Solid Analysis Measurements provide useful information about the insulating of solid material like paper, rubber, ceramic etc.

5 Functional Description

5.1 System Overview

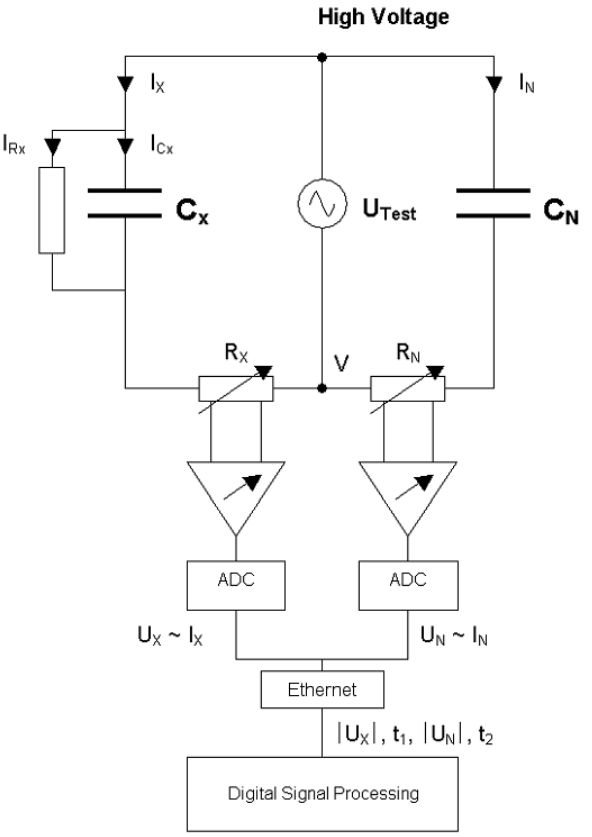
To be able to execute correct and reproducible measurements it is essential to understand how the measuring system works.

5.1.1 C & tan δ

The 2830 C & tan δ measuring system is based on the double vector-meter method which relies upon the measurement of the current I_N through the known reference capacitor C_N and the measurement of the current I_X through the unknown test object C_X.

Both branches are energized by the HV AC power source (U_{Test}) which is built in the 2831. Both currents are measured by the adjustable high accurate shunts R_X and R_N and then digitised. By using a sample number for each digitised value and a known sample rate a timestamp is calculated. With this technology not only the values but also the time information (phase displacement) between I_N and I_X can be measured very fast and highly accurate.

The digitised data streams are fed into the built-in PC of the 2830 and over the known standard capacitor built in the 2831. All other desired measuring values can now be determined online.

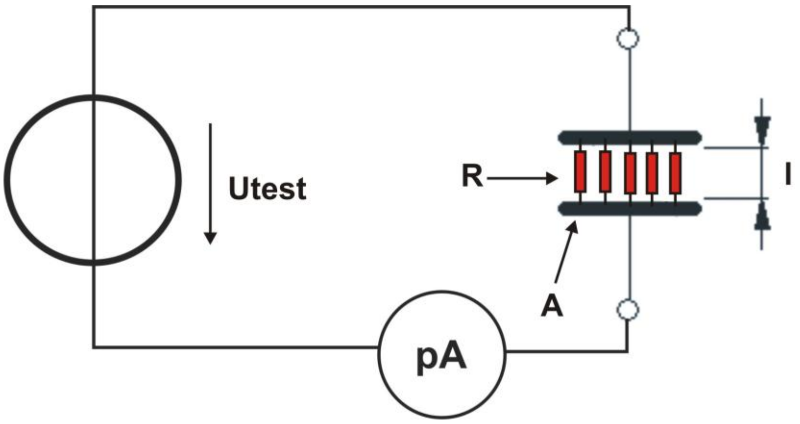


I_X	Current trough Device Under Test C_X
I_N	Current trough known Standard Capacitor C_N
I_{RX}	Losses of the Device Under Test C_X
C_X	Test Object (ideal capacitance)
C_N	Standard capacitor (with tan $\delta < 10^{-5}$)
R_X	Measuring shunt for I_X, C_X
R_N	Measuring shunt for I_N, C_N
V	Low voltage point of the HV supply and reference point of the measurement
ADC	Analogue to Digital Converter
t_1, t_2	Time stamps of the measured values

5.1.2 DC Resisitivity

The DC Resistivity measurement is based on a pico ampere meter built-in the 2831 which measures the current through the liquid or solid test cell. The HV DC source built-in the 2831 energizes the test cell so that a current can flow through the solid or liquid sample and the pico ampere meter. The applied voltage and the measured current are converted to digital values for further calculations in the 2830.

To calculate the resistivity, four parameters has to be known: The Ix through the solid or liquid sample, the applied voltage Utest, the surface area of the measuring electrode A and the thickness of the test sample l. In the chapter 4.5 DC Resistivity the calculation is explained in detail.



5.1.3 $V_{(Common)}$ point and Guarding

This measuring system is able to measure capacitances with highest accuracy to determine trending analysis of insulating materials. In the range of normal insulation capacitances the always existent stray capacitances - measured together wit the DUT – can influence the measuring values significant. So these unwanted stray capacitance effects have to be eliminated.

This is realized by the so called “guarding” of the relevant elements. That means that the complete high voltage source, the supply and measuring cables have to be shielded with the so called “$V_{(Common)}$” which is the low voltage point (reference) of the high voltage supply. All capacitances connected to this reference point are bypassed and are therefore not influencing the measuring value. Several parts have to be double shielded (Guard and Ground) to compensate other side effects and to ensure the specified measuring accuracy. Due to this guarding concept the supplied shielded coax measuring cables (for High Voltage Supply, Input Cn and Input Cx and input a) have to be used always. If the system is connected with normal unshielded cables the measuring values will be incorrect.

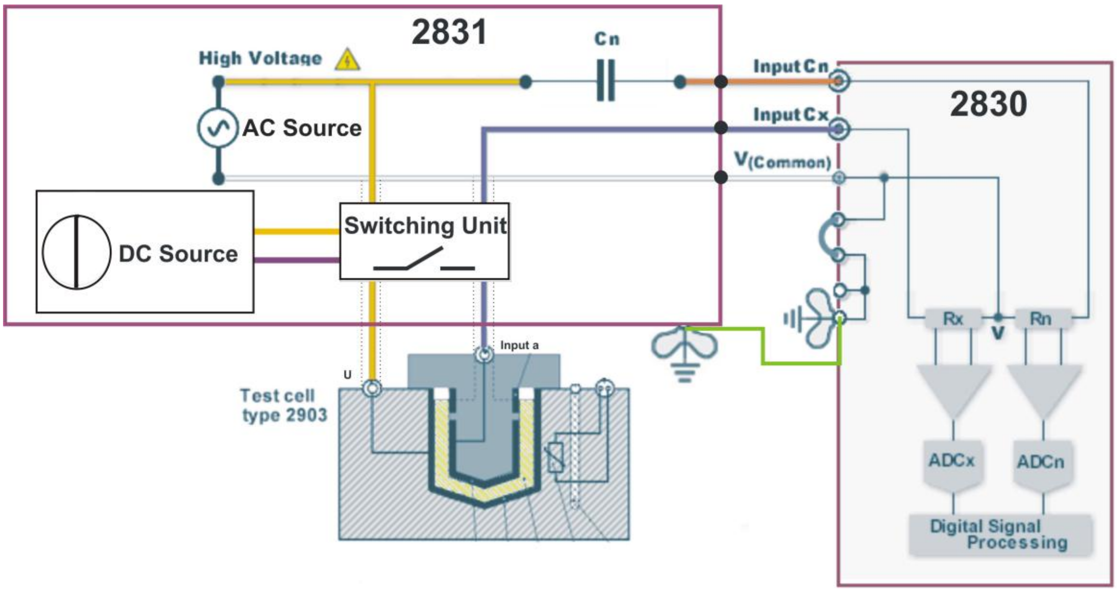
To keep in mind for the user of the system is that capacitances related to the $V_{(Common)}$ -point are bypassed. Make sure that all unwanted capacitances are related to the $V_{(Common)}$ point and their current is flowing directly into the $V_{(Common)}$ -point and not through the measuring shunt $R_{X.}$

This has to be evaluated for every measuring setup. The most common ones are described in this manual – for the other ones the user has to make sure that only the desired capacitances are measured with the chosen test setup.

The $V_{(Common)}$ point is accessible over 4mm plugs on the instruments back panel where the user can connect external parts of his test setup.

5.2 Standard test circuits

In this chapter the standard measuring methods are explained. It is important to understand how the current is flowing in the specific measuring application to avoid leakage currents which lead to inaccurate measurement results. These circuits are also applicable to Inductances.



Standard connection to measure capacitance and tan δ of liquid or solid insulating material between high voltage "u" to low voltage "a". Connection earth to $V_{(Common)}$ has always to be closed, else the high voltage can occurred on the $V_{(common)}$.

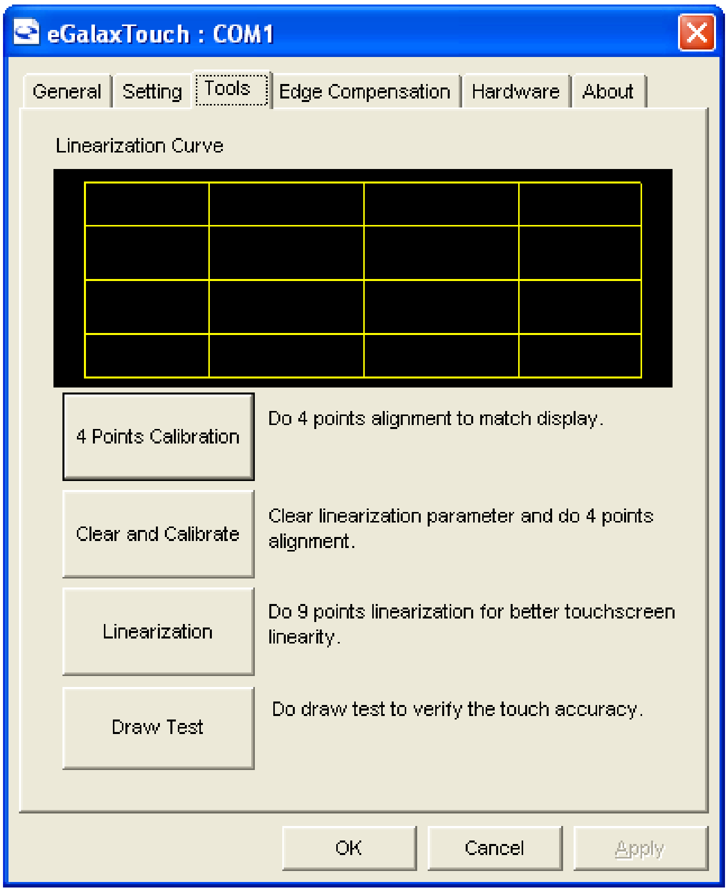
6 Operation Elements

6.1 Touch screen

To calibrate the touch screen positioning follow the following steps:

- Close or minimize the application software by pressing the minimize button or the close button.

- Start “All Programs” / “eGalaxTouch” / “Configure Utility”
- Switch to tab “Tools”
- The following screen will appear:



- Click on “4 Points Calibration” and follow the given instructions.

6.2 Front Panel 2830

1 Touch screen interface

2 USB Interface 1

3 USB Interface 2

4 Mains Power Switch

6.3 Rear Panel 2830

1 **Measurement Input Cx**

2 **Measurement Input Cn**

3 **V(Common)** (Reference Point of the bridge)

4 **The black jumper must always be connected to the V(Common)**

If the black jumper is not connected and High Voltage is switched on HIGH VOLTAGE can occurred on the V(Common) point.

5 **Earth connection**

6 **V(Common) terminal to connect to the 2831 V(Common).** (internally connected 6 to 3)

7 **Ethernet Interface**

8 **USB Interface 3**

9 **USB Interface 4**

10 **Safety Ground Connection**

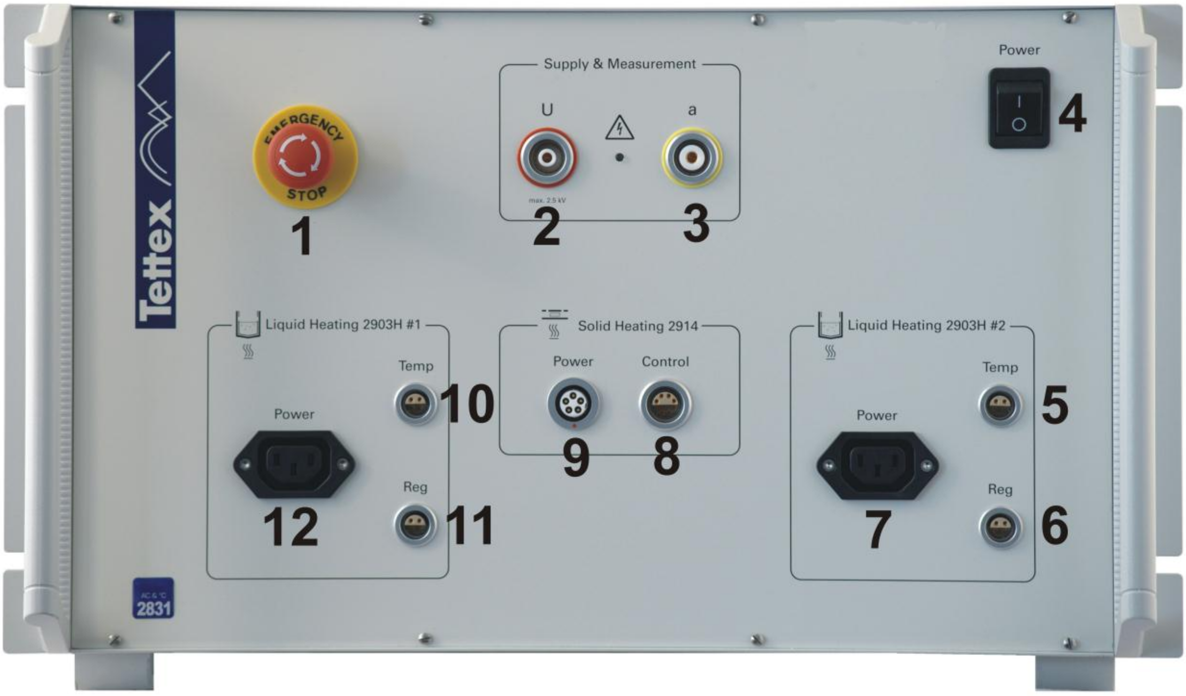
For safety reasons this earth cable should be the FIRST lead to be connected to the set and the LAST to be disconnected.

11 **Mains Power Switch**

12 **Mains Fuse**

13 **Mains input socket**

6.4 Front Panel 2831



1. Emergency Switch (Stops AC & DC power supplies and all heaters)
2. HV plug socket for liquid and solid test cell
3. Measuring plug socket for liquid and solid test cell
4. Main power switch
5. Temperature control for liquid heating #2
6. Temperature regulating for liquid heating #2
7. Power for liquid heating #2
8. Temperature control and regulating for solid heating
9. Power for solid heating
10. Temperature control for liquid heating #1
11. Temperature regulating for liquid heating #1
12. Power for liquid heating #1

6.5 Rear Panel 2831

1 **Measurement Output Cx**

2 **Measurement Output Cn**

3 **V(Common)** (Low Voltage Point of the internal AC power supply)

4 **Interlock 1**

5 **Interlock 2**

6 **Safety Ground Connection**

For safety reasons this earth cable should be the FIRST lead to be connected to the set and the LAST to be disconnected.

7 **Ethernet Interface**

8 **USB Interface 5**

9 **Fuse F1**

10 **Fuse F2**

11 **Mains input socket**

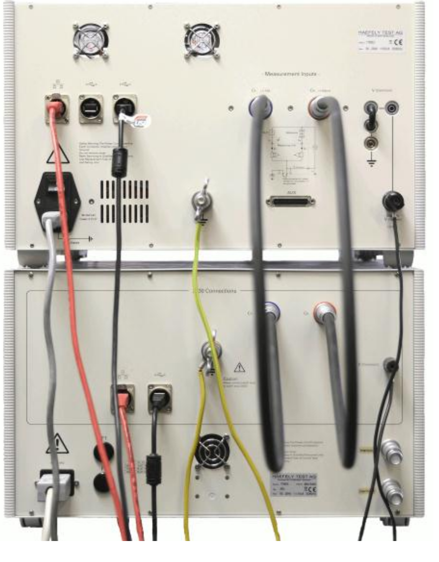
7 Installation of 2830/2831

7.1 Mounting of 2830 and 2831

There is no special recommendation to install the oil tester. A ideal position to mount the 2830/2831 is, to put the 2831 on the table and the 2830 on top of the 2831 (see the picture on the left side).

Check that the main switches are switched off

7.2 Inter-Wiring of 2830 and 2831



For the inter wiring of the 2830 and 2831 use only the cable which are delivered with the instrument.

- Connect the 2830 C_X to the 2831 C_X
- Connect the 2830 C_N to the 2831 C_N
- Connect the 2830 "V"$_{(Common)}$ to the 2831 "V"$_{(Common)}$
- Connect the 2830 "Earth" to the 2831 "Earth"
- Connect the 2830 "LAN" to the 2831 "LAN"
- Connect the 2830 "USB" to the 2831 "USB"

- Connect the Interlock 1 and 2. The two interlock plugs are part of scope of supply.

- Connect the main power cable after checking that the main switches are off.

8 Software

8.1 Software

The Software is running on a embedded Microsoft Windows Operation System. The software is designed to control all operation and inputs by a touch screen. Additional peripherals like a printer, an USB mouse or an USB keyboard etc. can be connected to the system for easier operating.

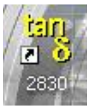
The Windows operating system and also the instrument application software are installed and tested before delivering.

This software chapter describes only the instrument application and not the Windows operating system.

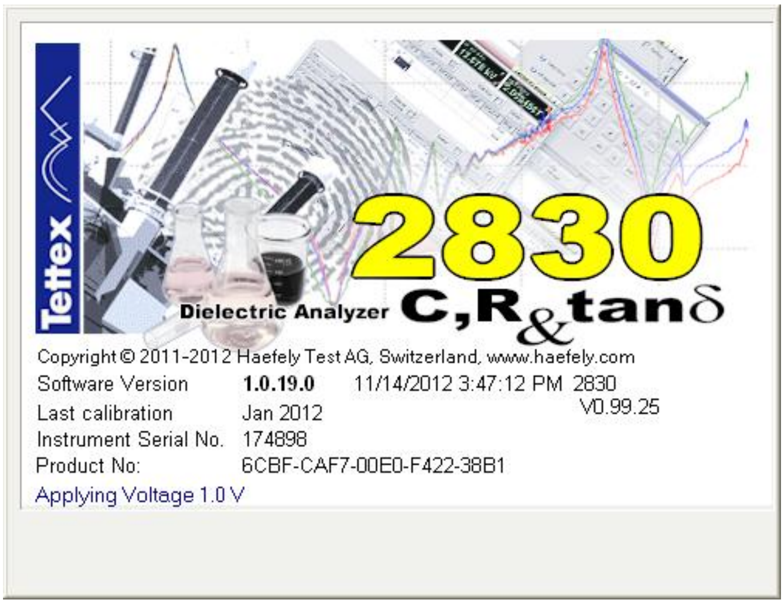
8.2 General

8.2.1 Start Up

After the system is switched on and the Windows 7 Embedded is started up the 2830 software will automatically start up with a delay of 10 seconds.
To start the 2830 software manually - this case could be after closing the software and not shutdown the devices - double click on the following link on the desktop:



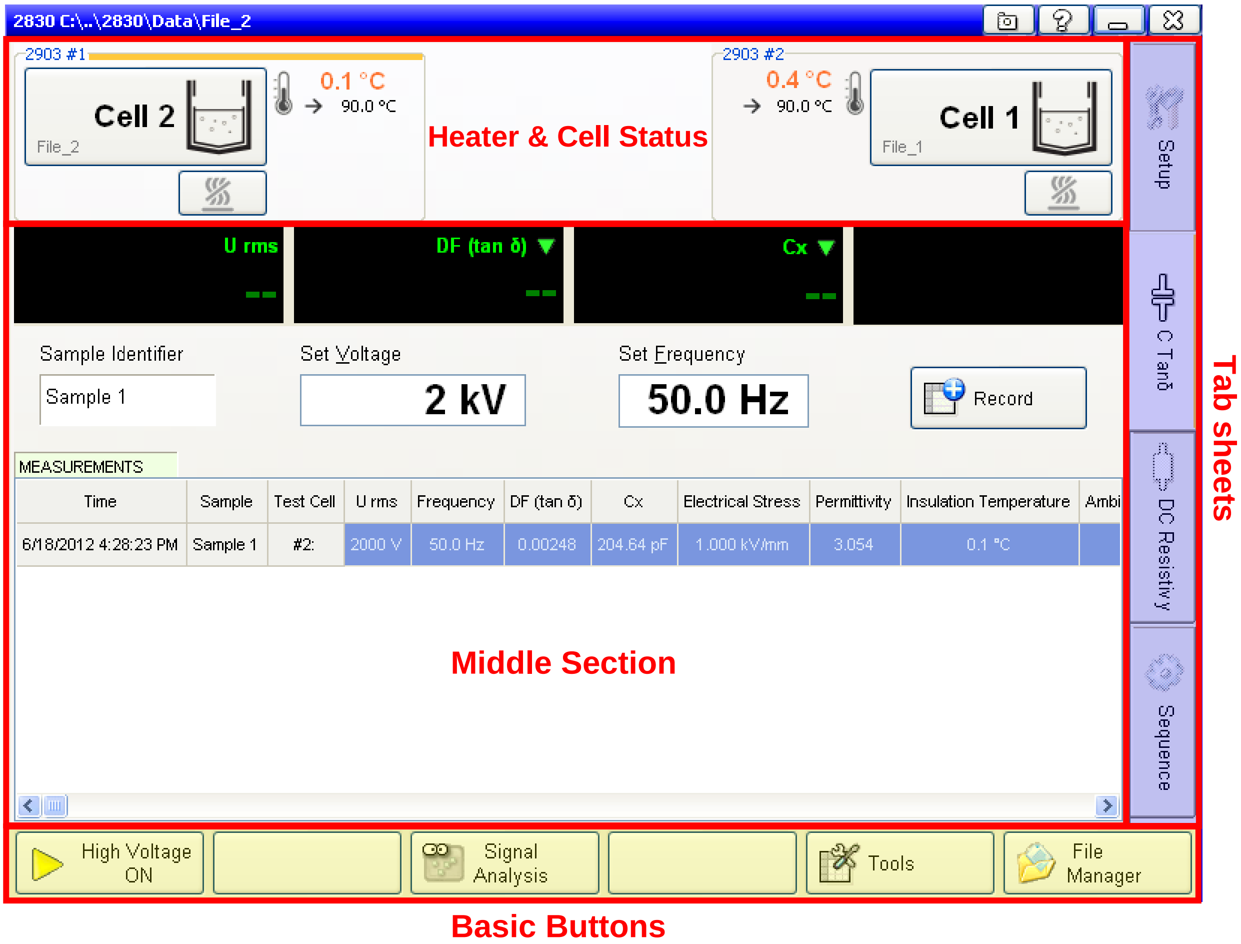
The following image shows the start up screen of the 2830 software. The displayed software version can be different as the actual which you have.



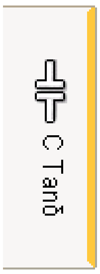
Once the program has been started the last opened tab sheet appears: e.g. C Tan δ with selected heater 2903 #1.

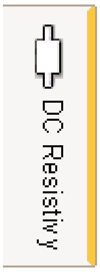
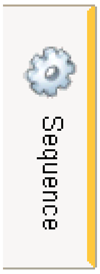
8.2.2 Basic Window Structure

The software consists of one window with multiple tab sheets on the right side. The buttons on the bottom are dynamic assigned depending on the selected tab sheet. The heater & cell section on the top is also dynamic. It could display either one to two liquid heater, to which one liquid test cell can be assigned, or one solid test cell depending on the heater selection (see 8.4.3 Heating Cell(s)). The Setup tab sheet has no heater & cell section. The middle section, where the measuring values are displayed and stored and the voltage, frequency, electrification time etc. can be set, looks almost the same for the “C Tanδ” and the “DC Resistivity” tab sheets. The other two tab sheets have each a different looking.



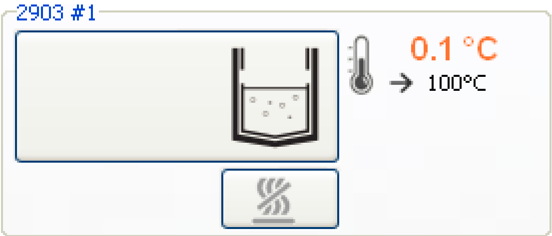
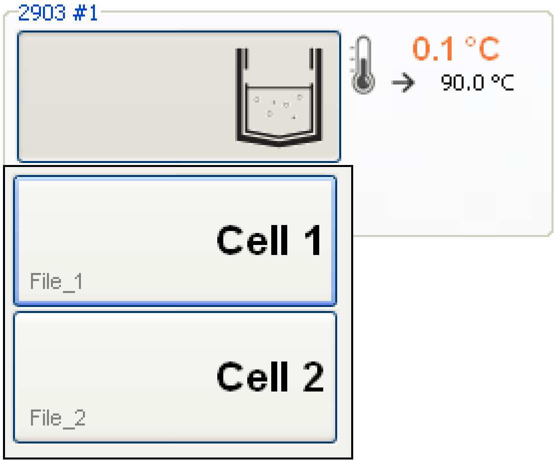
Following tab sheets can be selected:

	**Setup** This sheet provides access to the definition of the device under Test (DUT), measuring conditions, test cell settings, heating controller settings, options and auxiliary information. See chapter 8.4 Setup for further details.
	**C Tan δ** This sheet is used for manual measuring C Tanδ and permittivity. Several further settings, such as the AC voltage & frequency, can be set. The measuring results can be managed in the spreadsheet. See chapter 8.5 C Tan δ for further details.

	**DC Resistivity** This sheet is used for manual measuring of DC Resistivity. The DC voltage, polarity, shorting time and measuring time can be set and the measuring results can be managed in the spreadsheet. See chapter 8.6 DC Resistivity for further details.
	**Sequence** This tab sheet defines the test sequence and create complex test cycles. The measured data are automatically stored in the according spreadsheet. At the end of a sequence a report will be generated automatically. See chapter 8.7 Sequence for further details.

8.2.3 Heater & Cell Status

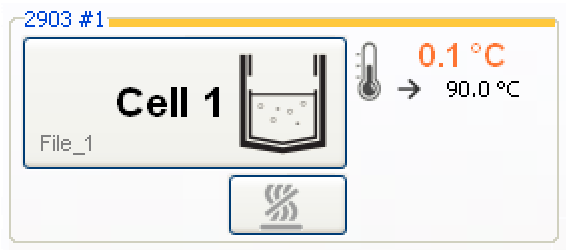
The symbol for the liquid heater in the heater & cell section can have following looking and information:

	**Liquid Heater 2903 #1** Depending on the heater selection (see chapter 8.4.3 Heating cells) you can see one or two liquid heater in the heater & cell section. If no heater is selected then the this section is empty. When the 2830 software is started, then no test cell and file is assigned to the heaters.
	**Assigning a Liquid Test Cell** Before a measurement can be made a liquid test cell has to be assigned to a heater, else the HV can not be switched on. With the test cell assigning the according file will also be loaded (on the picture on the right side are two cells with the according filename in the lower left corner). To assign a test cell to the heater the button with the test cell symbol on it has to be clicked. Then a list with all defined liquid test cells appears depending on the cell definition on the tab sheet “Settings” (see chapter 8.4.2). Click on the cell which is installed for this example in heater #1.

Deassigning the Liquid test cells

To reset the assigning of the liquid test cells to the heaters it has to be clicked in a red marked area between the two test cells.

Liquid Heater and Test Cell Status



After assigning a liquid test cell to the heater the number of the selected test cell and the assigned file name will be displayed.

Beside the thermometer the current liquid temperature (orange number) and the set target temperature (see chapter 8.4.3 Heating Cell(s)) is displayed.

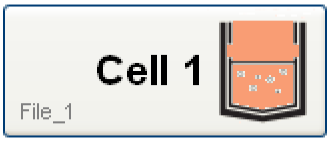
The orange bar on the top signals that this test cell, heater and file is selected for measurement.

Switch On/Off the Heater

By pressing this button you can switch on and off the heater.

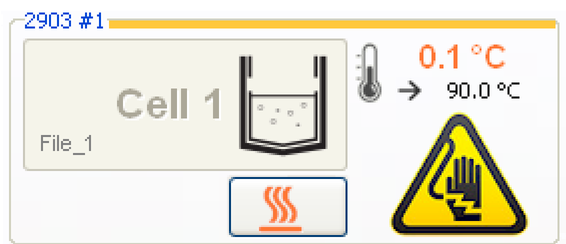
The symbol indicates the current state of the heater: a grey symbol means the heater is off and a red symbol means the heater is running.

Hot Test Cell



When the test cell temperature is higher than 45 °C, then the cell color changes to red. Then the cell should not be touched without a heat protection means such as clothes.

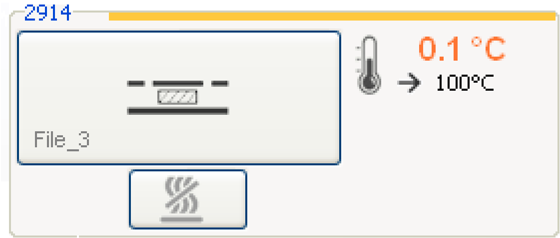
During a Measurement

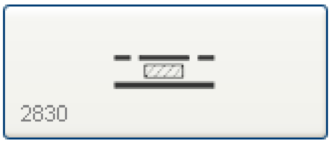


After assigning a liquid test cell to a heater the HV On/Off button is enabled and the measurement can start.

During a measurement the button for the cell assigning is disabled but not the heater On/Off button. Additional a HV warning symbol appears. This symbol appears during AC or DC HV is applied and also during a cell shorting phase.

The symbol for the solid test cell in the heater & cell section can have following looking and information:

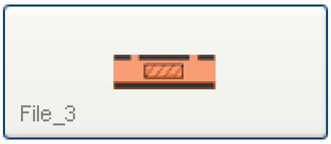
<table>
<tr>
<td>

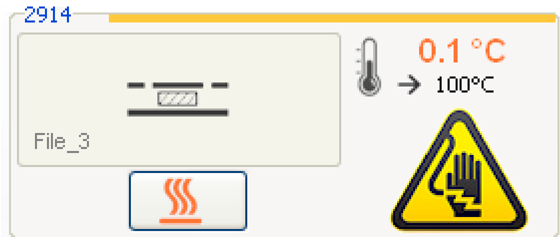

</td>
<td>Solid Test Cell Status

To make solid measurements the solid heater has to be selected in the heater selection (see chapter 8.4.3 Heating Cell(s)) then no liquid heater can be selected.

Other than the liquid heater and test cell the solid cell is one part. It includes the heater and the electrodes with guard-ring. Therefore no cell has to be assigned to a heater.

When the 2830 software is started, then a temporary file (visible in the right bottom corner of the cell symbol: 2830) will be generated. The measurement can be done with this file. When the software is closed or the heater is changed, then a dialog asks if the temporary file should be stored with a different filename. If the file is not stored, then the measurement results will be deleted. It is recommended to make a new file or open an existing one before the measurements start. (see chapter 8.3 File Manager)

Beside the thermometer the current liquid temperature (orange number) and the set target temperature (see chapter 8.4.3 Heating Cell(s)) is displayed.</td>
</tr>
<tr>
<td>
</td>
<td>Hot Test Cell

When the test cell temperature is higher than 45 °C, then the cell color changes to red. Then the cell should not be touched without a heat protection means such as clothes.</td>
</tr>
<tr>
<td>
</td>
<td>During a Measurement

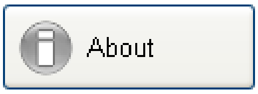
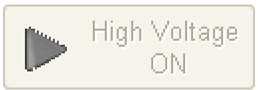
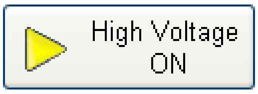
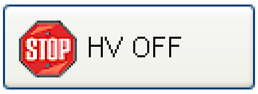
During a measurement the cell symbol is disabled but not the heater On/Off button. Additional a HV warning symbol appears. This symbol appears during AC or DC HV is applied and also during a cell shorting phase.</td>
</tr>
<tr>
<td>
</td>
<td>Switch On/Off the Heater

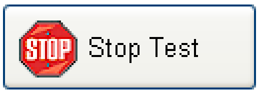
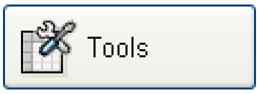
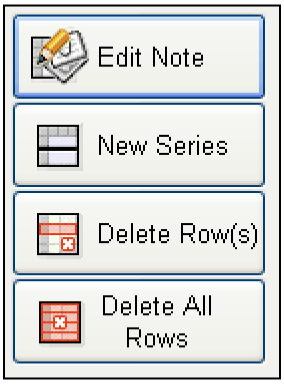
By clicking on this button you can switch on and off the heater.

The symbol indicates the current state of the heater: A grey symbol means the heater is off and a red symbol means the heater is running.</td>
</tr>
</table>

8.2.4 Basic Buttons

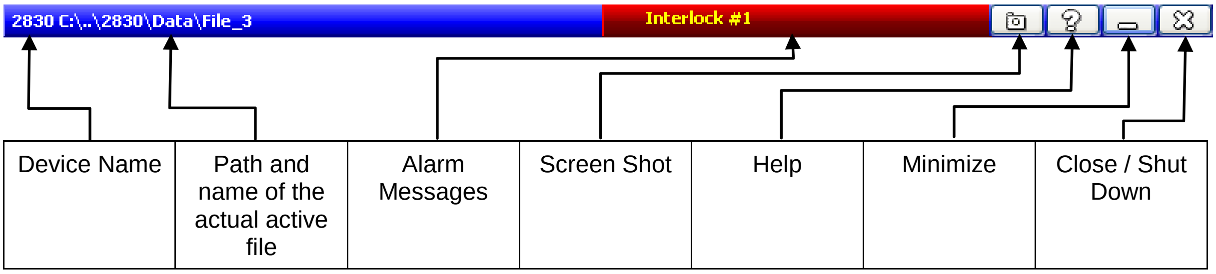
In the basic buttons area are following buttons available depending on the selected tab sheet:

	**About** By clicking on this button the about pop up with software & firmware versions and other info will appear (see chapter 8.4.6 About Screen). Available on tab sheet: Setup
	**File Manager** By clicking this button the file manager will open where the file management can be done. (see chapter 8.3 File Manager) Available on each tab sheet.
	**Disabled HV On/Off** When no heater is selected or no liquid test cell is assigned the HV On/Off button is disabled and the measurement can not be started (see chapter 8.5 C Tan δ). Available on tab sheet: C Tan δ
	**HV On** By clicking on this button the AC HV will be applied and the measurement starts (see chapter 8.5 C Tan δ). Available on tab sheet: C Tan δ
	**HV Off** By clicking on this button the AC HV will be shut down and the measurement ends (see chapter 8.5 C Tan δ). Available on tab sheet: C Tan δ
	**Analysis** When this button is clicked a signal analysis window will appear with several tools to analyze the measurement signal (see chapter 8.5.1 Signal Analysis) Available on tab sheet: C Tan δ
	**Disabled StartTest** When no heater is selected or no liquid test cell is assigned the StartTest button is disabled and the measurement can not be started (see chapter 8.6 DC Resistivity). Available on tab sheet: DC Resistivity
	**Start Test** By clicking on this button the DC HV will be applied for the set measuring time and the resistivity measurement starts (see chapter 8.6 DC Resistivity). Available on tab sheet: DC Resistivity

	**Stop Test** By clicking on this button the DC HV will be shut down and the measurement aborts (see chapter 8.6 DC Resistivity). Available on tab sheet: DC Resistivity
	**Disabled Start Shortingt** When no heater is selected or no liquid test cell is assigned the Start Shorting button is disabled and the shorting can not be started (see chapter 8.6 DC Resistivity). Available on tab sheet: DC Resistivity
	**Start Shorting** By clicking on this button the test cell will be short circuit for the set shorting time (see chapter 8.6 DC Resistivity). Available on tab sheet: DC Resistivity
	**Stop Shorting** By clicking on this button the test cell short-circuit will be stopped (see chapter 8.6 DC Resistivity). Available on tab sheet: DC Resistivity
 	**Tools** By clicking on this button a button list will appear with some tools to edit the spread sheet with the recorded measurements result on the C Tan δ & DC Resistivity tab sheets. The button list can also be opened by a right click in the result table. **Edit Note** Create or edit a note on the selected entry in the table. **New Series** A empty row will be insert in the spread sheet. **Delete Rows** Selected rows will be deleted in the spread sheet. **Delete all Rows** All rows will be deleted in the spread sheet. Available on tab sheet: C Tan δ & DC Resistivity

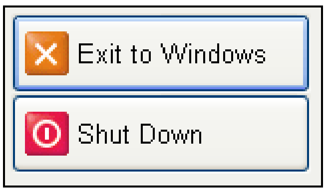
8.2.5 Title Bar

The title bar (header line) has following structure:



The color of the title bar will change to red while the AC or DC HV is switched on:

The functional descriptions of the title bar elements are:

2830	**Device Name** Name of the device.
C:\..\2830\Data\File_3	**File Name** The actual active (loaded) test file and its path is shown here. All data are stored in this file.
Interlock #1	**Alarm Message** In this area the alarm messages will be displayed (see chapter 8.2.6 Alarm Messages).
	**Screen Shot** This button can be used to generate and save a screenshot. If clicked on a dialog pops up which asks where to store the picture file.
	**Help** By clicking on this button the instruction manual will be open as PDF file.
 	**Minimize** The window will be minimized and you have access to the Windows OS desktop. On this button can only be clicked when no measurement is running else it is disabled.
 	**Exit** By pressing this button you can select between “Exit to Windows” and “Shut Down”. Click the “Exit to Windows” button to terminate the application software and exit to the Windows Operating System. Click the “Shut Down” button to terminate the software and shut down the system. It’s strongly recommend to shut down the system correctly before switching the main power off.

8.2.6 Alarm Messages

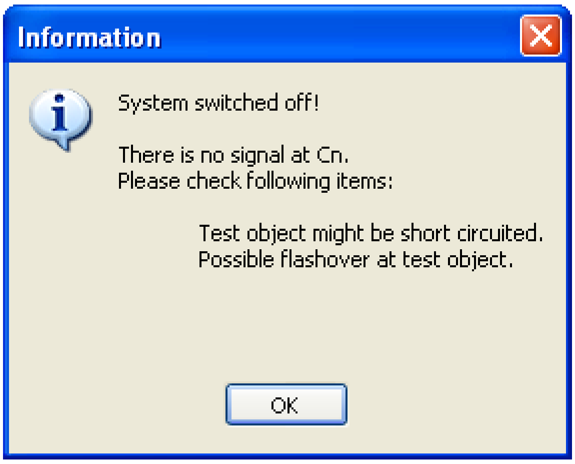
Following alarm messages could be displayed in the title bar (see chapter 8.2.5 Title Bar):

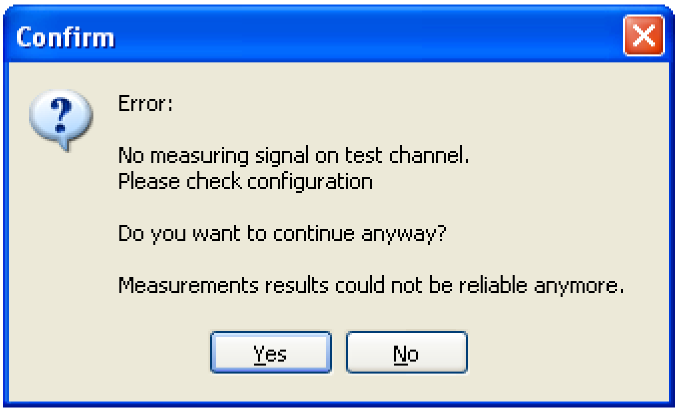
Interlock #1	**Interlock #1** The interlock of the liquid test cell 1 is open. Close the cover (if available) of the test cell or connect the interlock plug to the interlock 1 plug socket on the rear side of the 2831.
Interlock #2	**Interlock #2** The interlock of the liquid test cell 2 is open. Close the cover (if available) of the test cell or connect the interlock plug to the interlock 2 plug socket on the rear side of the 2831.
Emergency	**Emergency** The emergency button on the front panel of the 2831 is pressed. Unlock the button by turning it clockwise.
Emergency or Interlock not connected.	**Emergency or Interlock not connect** When this alarm messages will be displayed then the emergency button on the front panel is pressed and one or both interlock plugs are not connected. Unlock the emergency button by turning it clockwise and check both interlock plugs or close the cover (if existing) of the test cells.
2830 not connected.	**2830 not connected** If the measuring hardware of the 2830 is not ready or the internal communication is broken then this alarm messages will be displayed. Shut down the system and restart it.
2831 not connected.	**2831 not connected** This alarm message will be displayed when no communication between the 2830 and 2831 over Ethernet is possible. Check the Ethernet cable on the rear panel of both units.
AC Current Trip (I > 5mA)	**AC Current Trip** If the AC measuring current during a C Tanδ measurement exceed 5 mA then the HV and the heater will be switched off, a actual running sequence will be aborted and this alarm messages will be displayed. Check the test cell for flashover, short-circuits and minimal impedance. To detect a flashover apply a low voltage and increase the voltage in small steps until the flashover occurs. The alarm message can be quitted by clicking on it.

DC Current Trip (I > 3mA)	**DC current Trip** If the DC measuring current during a DC Resistivity measurement exceed 3 mA then the HV and the heater will be switched off, a actual running sequence will be aborted and this alarm messages will be displayed. Check the test cell for flashover, short-circuits and minimal impedance. To detect a flashover apply a low voltage and increase the voltage in small steps until the flashover occurs. The alarm message can be quitted by clicking on it.
Old 2967 Heater Cable is plugged in	**Old 2967 Heater Cable is plugged in** When a control cable of the old Tettex 2967 heater controller is used to connect the solid test cell 2914 with the 2831 then this alarm message will be displayed. Use controller cable which is delivered with the 2830/2831 system.
Solid Control cable switched	**Solid Control cable switched** When the control cable of the solid test cell 2914 is connected reversely this alarm message will be displayed. Disconnect the control cable and connect it reversely.
Temp/Reg Cables switched	**Temp/Reg Cables switched** Because of safety issues an alarm message will be displayed and the heater switched off if the liquid test cell temperature is 25 °C hotter than the heater temperature. It is supposed that the Temp and Reg control cables are connected wrong on the 2831 front panel. This message could also be displayed when a hot liquid test cell is put in a cold heater. Check if the two cables are connected in the correct plug socket (the cables are labelled). If the liquid test cell is hotter than 25° C as the heater then take the test cell out of the heater and preheat the heater for a short time without the test cell inside. After the preheating try again to start the heating with the hot cell inside.

8.2.7 Error Messages

Following error messages will appear in a dialog window when a error occurs

	**Error Ethernet Connecting 2831** When at the software start up no communication to the 2831 over Ethernet could be established this error message pops up. Close the 2830 application and check the Ethernet cable for correct installation and restart the application.
	**Error USB Connecting 2831** When the USB communication fails at the software start up then this error message pops up. Close the 2830 application and check the USB cable for correct installation and restart the application.
	**Fatal Error** This error can occur after a DC flashover in the test cell. Shut down the system and switch off both units. Then switch them on and start the 2830 application.
	**No Signal at Cn** When no current is measured on the Cn channel although the HV is applied then the HV is switched off. Check if the coaxial cable at the Cn plug sockets on the rear panels of the 2830 and 2831 is well connected. A further reason could be a short circuit or a flashover in the test cell.

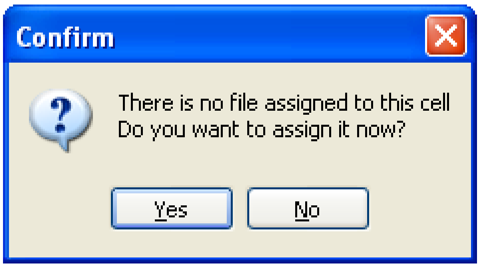


No Measuring Signal

When after a few seconds no signal is detected on the measuring channel Cx then this error message pops up. By clicking on Yes the measuring will continue, by clicking on No the HV is switched off and the measurement stops.

Check if the test cell is connected to the plug sockets “a” and “U” on the front panel of the 2831 and the connection between the plug sockets “Cx” on the rear panels of both units.

8.2.8 Information Messages

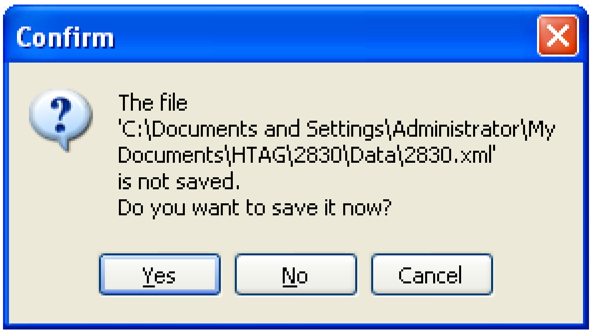


No File Assigned

If a liquid test cell is being assigned to a heater and no file is assigned to the test cell then this information message pops up and asks if a file should be assigned.

By clicking Yes the tab sheet “Settings” will be opened where the file name can be assigned to a liquid test cell.

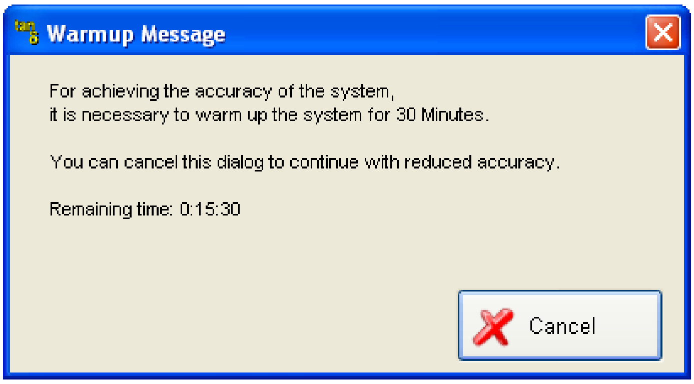
By clicking No the last opened file will be used to save the results and no file will be assigned to the selected test cell.



Not Saved

Each time when the solid test cell is being selected the temporary file 2830.xml is created.

If then no file is loaded or created before a measurement will be recorded and the solid cell is being deselected then this dialog pops up. If no is clicked all recorded values will be deleted.



Warmup Message

To achieve the full accuracy the system needs a warm up time of 30 minutes. If the 2830 application is started without waiting 30 minutes then this information message pops up and count the remaining time down.

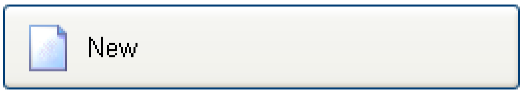
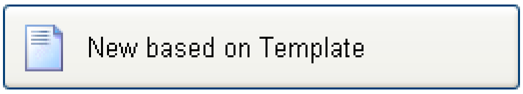
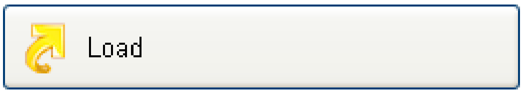
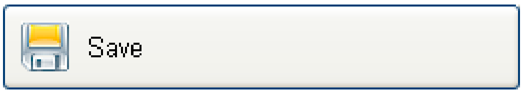
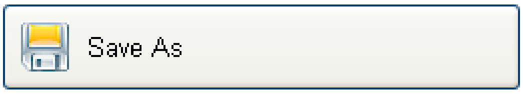
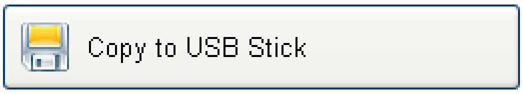
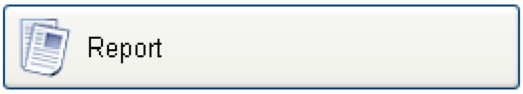
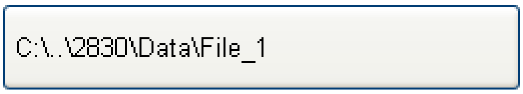
By clicking on cancel the countdown is stopped and the dialog is closed. But if this is done then the accuracy is reduced.

8.3 File Manager

With the help of the File Manager several basic file operating such as create, save, load etc. can be done. The standard path for the saving and loading dialog is the subfolder “Data” of the set Data Directory in the sub tab sheet Options (see 8.4.4 Options).

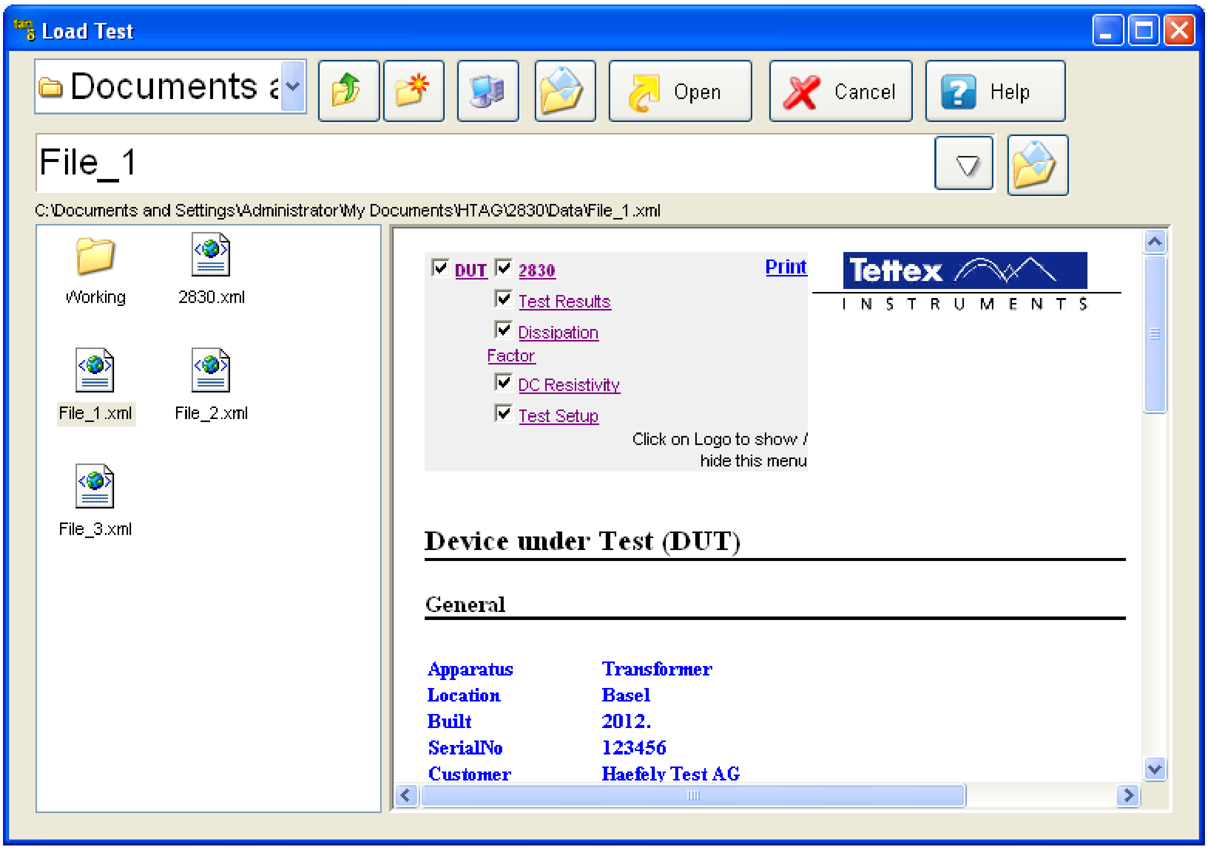
On each tab sheet the File Manager can be accessed by clicking on the following button on the bottom right of the window

By clicking the this button a window with a button list pops up. The buttons have following functions:

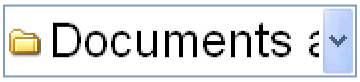
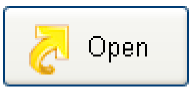
	**New** The File Selector Dialog pops up where you can enter a name for the new file.
	**New based on Template** The File Selector Dialog pops up and a new test file can be generated which will be based on an existent file. The DUT Info will be used from the source file, the measuring data will be deleted. All further operations will be stored in this file.
	**Load** Load an existing file.
	**Save** To save the actual test file.
	**Save As** The actual file can be saved with a different filename.
	**Copy to USB Stick** To copy the actual file to your USB stick.
	**Report** The internet explorer with the actual test file will open. There you can print the file and configure the appearance of the document. See chapter 8.3.2 Report for more information.
	**Previous Test(s)** Last three used files are displayed for quick access.

8.3.1 File Selector Dialog

The dialog is used for storing, loading, previewing and moving files inside the directory.



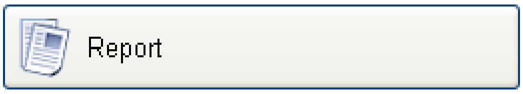
The elements have following functions:

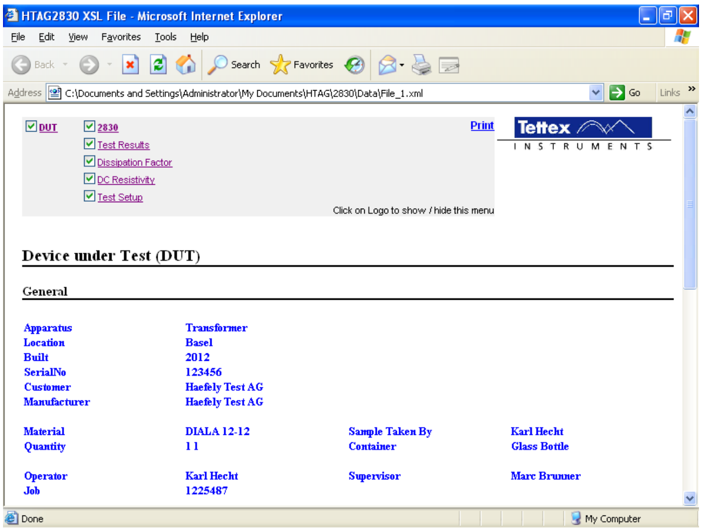
	**Directory** Drop-down list to select the actual directory.
	**Files** The selected file is displayed or a new filename can be entered. It is also possible to choose one from the last three loaded files by clicking on the arrow on the right side of the text input field.
	**Directory Up** Go up one directory in the hierarchy.
	**New Directory** Create a new directory in the actual path.
	**My Computer** The root of the file system is displayed. There you can select for example the USB memory stick for storage.
	**Open** This button will only be available if the open dialog is opened. Open a selected file. Select the file, or enter the name of an existing file.

	**Save** This button will only be available if the save dialog is opened. The current active file is stored under the actual “filename” in XML and CSV format.
	**Cancel** Cancel an close the file manager window.

8.3.2 Report

The Internet Explorer will be opened and the report of the actual file will be shown by clicking on the following button in the File Manager:





At the top of the explorer window a small header with six boxes and a print link is placed. With this menu the appearance of the printout can be controlled. It is possible to hide or display the DUT info, the test results, the Dissipation Factor measurements, the DC Resistivity measurements and the test setup. Clicking on the Logo on the right side of the explorer window will show or hide the menu. The “Print” Command will hide the menu and open the print dialog.

Change of Printout Logo

If you want to use your own logo, the only thing you have to do is to replace the file “`C:\company.jpg`” by your own logo.

Data Files

All measurement and sequence data are stored in both XML and CSV format:

CSV (**C**omma **S**eparated **V**alues) files can be used to export data to Microsoft Excel.

XML (e**X**tended **M**arkup **L**anguage) files have a hierarchical structure and can be easily displayed by any computer with a Web Browser.

To exchange data or move files to another computer you have to copy one or more of the following files:

`*****.xml`	The XML file, which you want to look at.
`*****.csv`	The CSV file with DUT Information and all measuring data.
`HTAG2830.xsl`	All information of the appearance of printing and showing are stored in this file. You have to copy this file only once into the root directory. For example if you want to copy the file anywhere on drive D, you should copy HTAG2830.xsl to D:\HTAG2830.xsl.
`company.jpg`	The logo picture has also to be copied in the root directory like the HTAG2830.xsl.

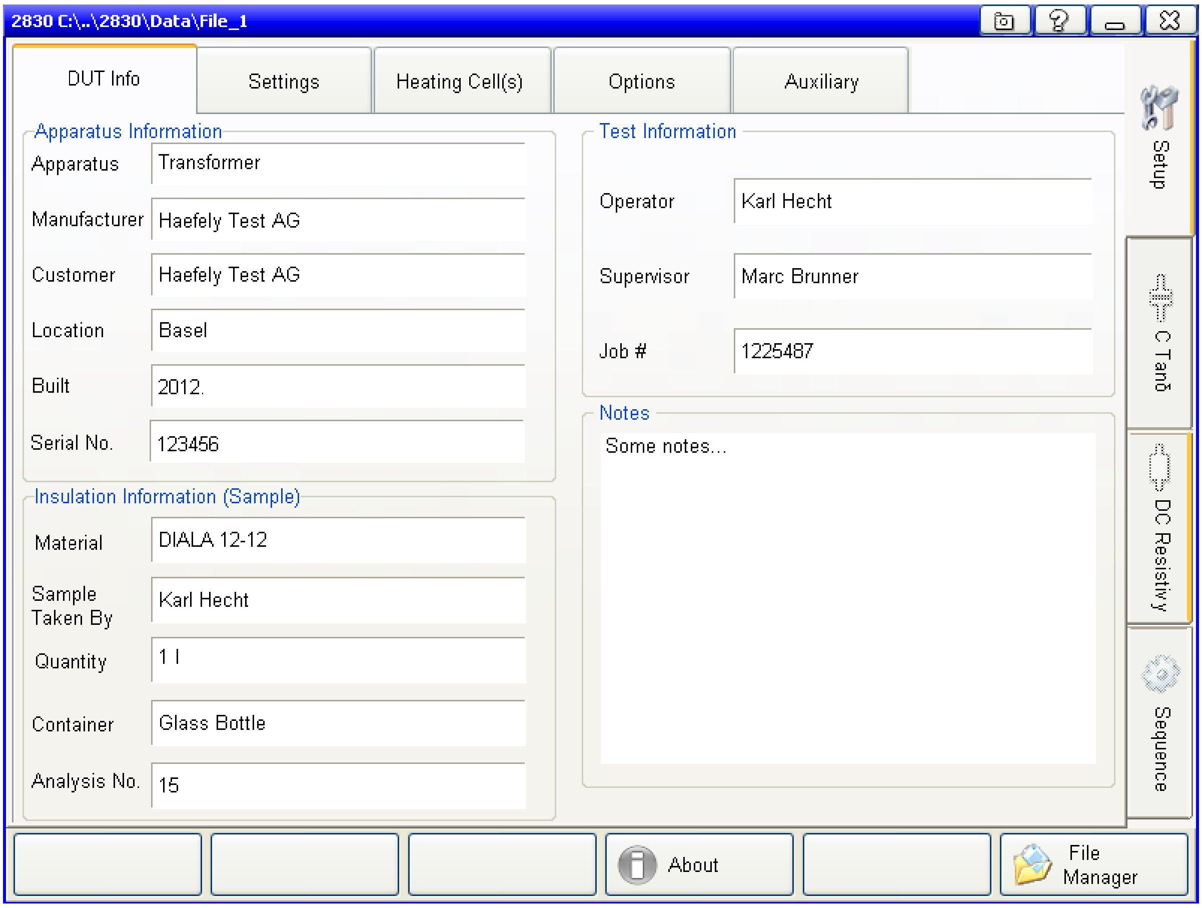
8.4 Setup

The Setup tab sheet consists of following sub tab sheets:

DUT Info	**DUT Info** General information about the device under test can be entered. See chapter 8.4.1 DUT Info.
Settings	**Settings** In this tab sheet, you should enter the quantity of liquid test cells in use and their specifications. For each cell you have to enter the “File Name”, the “Serial Number” the capacitance value of the empty cell @ the measured temperature and the calibration data when the empty oil test cell was measured. For the solid test cell you have only to enter the electrode distance. See chapter 8.4.2 Settings.
Heating Cell(s)	**Heating Cell(s)** Select either one to two liquid test cell heaters or one solid test cell. The temperature for each heater can be set individually. See chapter 8.4.3 Heating Cell(s).
Options	**Options** Several application options can be set: Temperature unit (Celsius or Fahrenheit), acoustic signal when HV is ON, keyboard mode, user input, data directory, factory settings, mandatory and languages. Currently the user interface is only available in English. See chapter 8.4.4 Options.
Auxiliary	**Auxiliary** Additional information for special purpose can be entered. This information will be included in the report file. See chapter 8.4.5 Auxiliary.

8.4.1 DUT Info

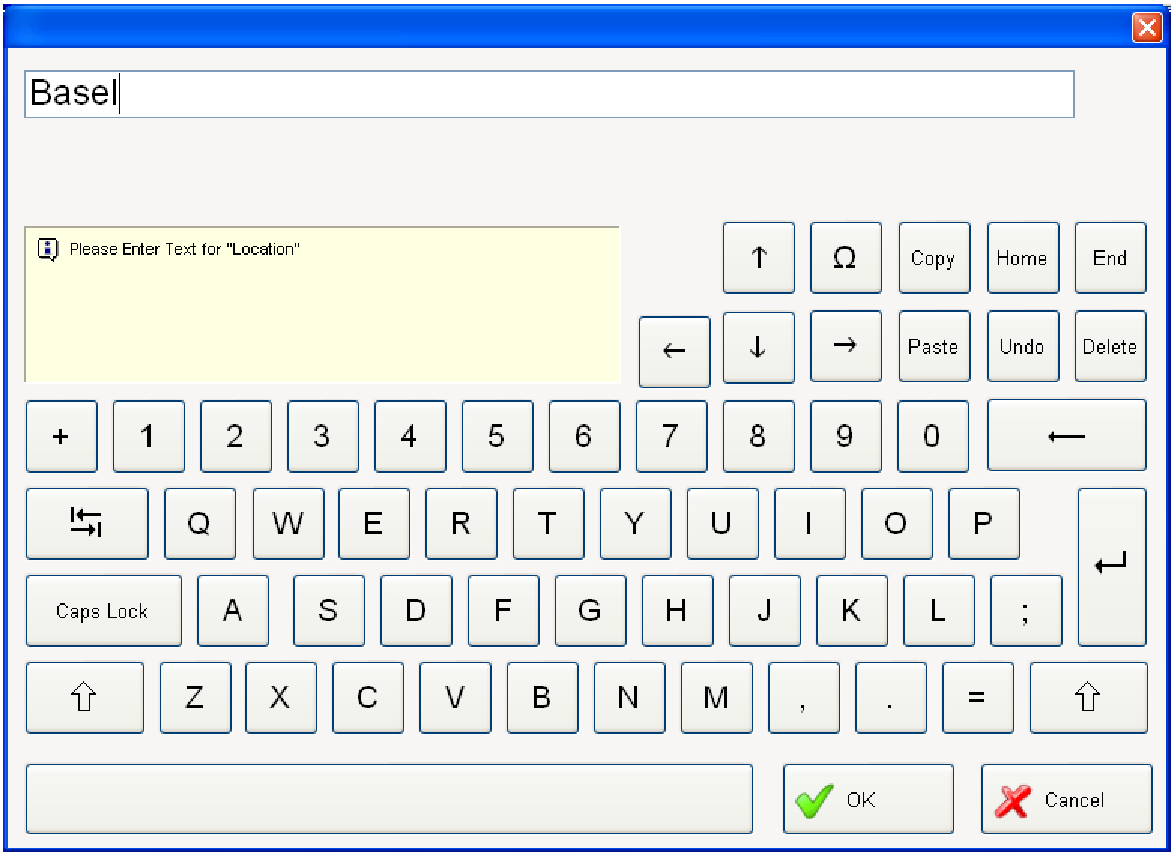
On this sub tab sheet information about the DUT (Device Under Test) could be filled in. This information will also be saved in the report file.



8.4.1.1 Touch Screen Keyboard

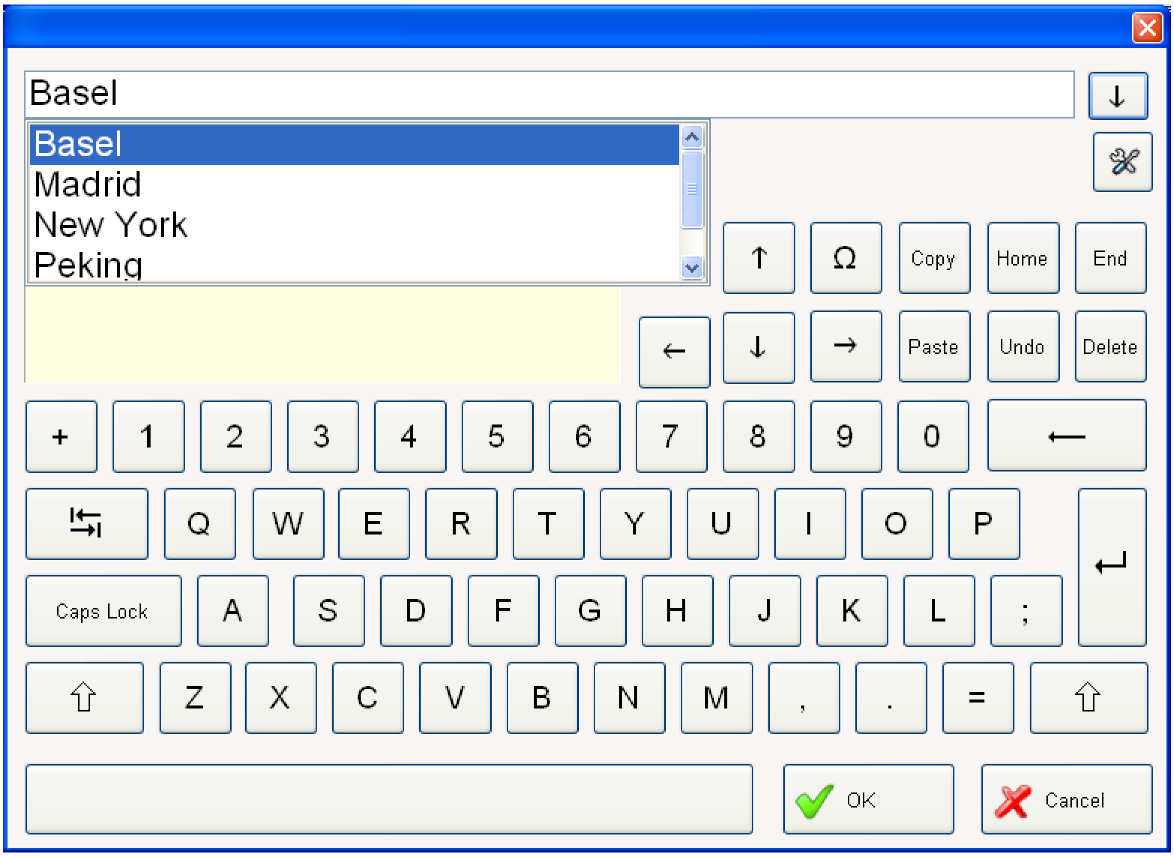
If “Touchscreen” is selected under the Keyboard option on the Options tabsheet (see 8.4.4 Options) a dialog with a software keyboard on it opens by clicking in a textfield. If the option “External” is selected no dialog will appear and the text can be filled in directly with the external keyboard.

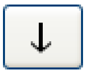
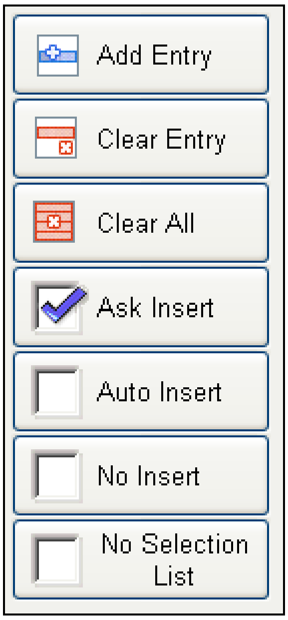
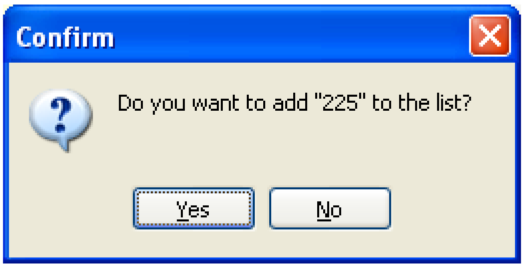
Once you have entered the text, you have to confirm it by pressing the “OK” or “Enter” button.



If “Use Input List” is selected under the User Input option on the Options tabsheet (see 8.4.4 Options) a list of the last typed text in the specific text field opens and the user can select one of this entries or type a new text.

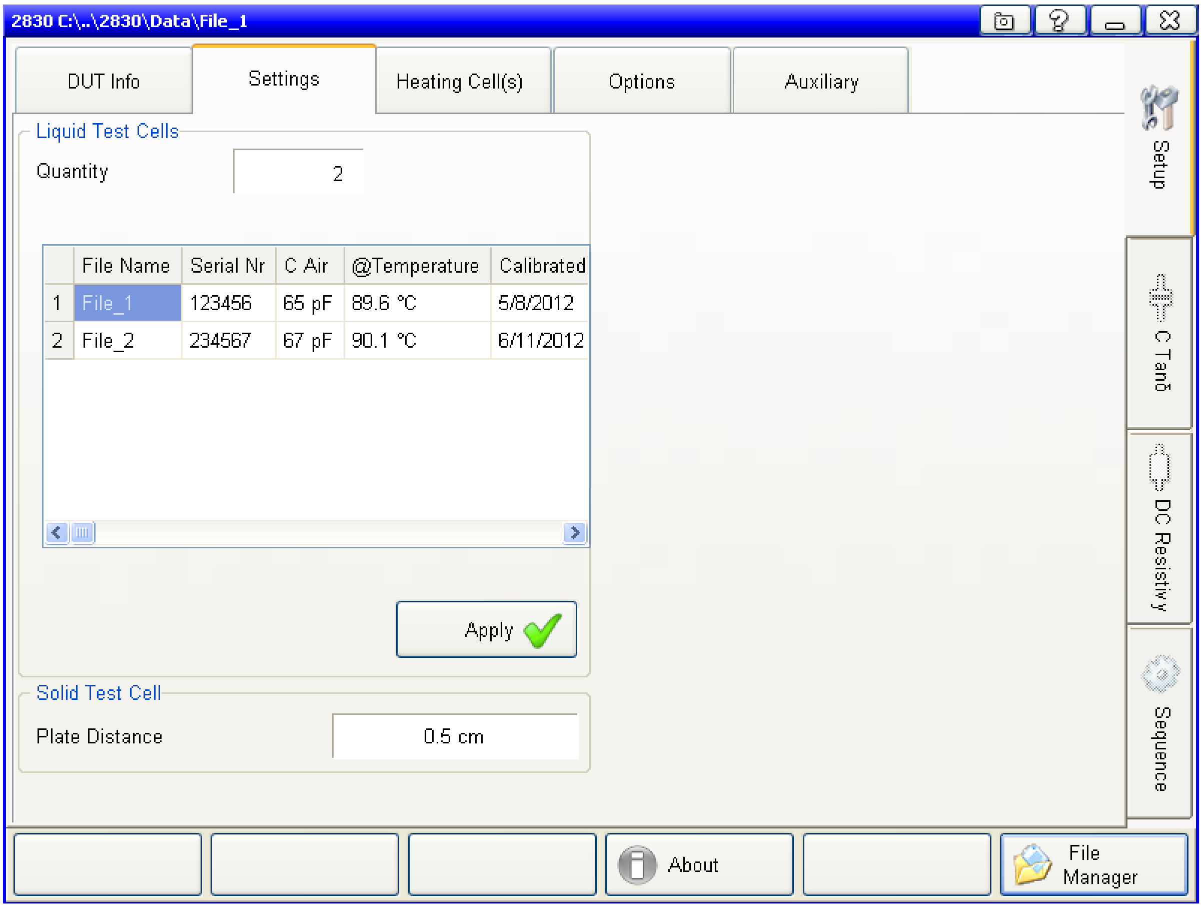
To edit the entries in the list click on the arrow beside the text field.

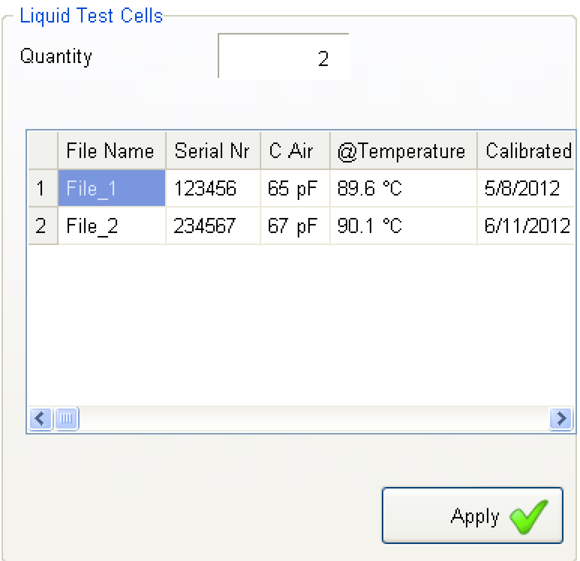


	**Show Selection List** By clicking on this button the last typed entries in the accordant text field will be displayed in the Selection List. Once something is typed in the text field the list will open automatically.
	**Entry Toolbox** The Entry Options List will open by clicking on this button-
	**Entry Options List** After clicking on the toolbox button this list with tools for editing the entries appears:. **Add Entry** Add the actual entry manually to the Selection List **Clear Entry** Clear the actual entry from the Selection List **Clear All** Clear the entire Selection List Only one of the following options could be selected at once: **Ask Insert** The “ADD to List Dialog” will be opened after a entry was typed in. **Auto insert** The entry is automatically saved in the Selection List without to open the “Add to List Dialog”. **No Insert** No entry will be saved in the Selection List. **No Selection list** Disables the Selection List and doesn’t save the entry.
	**Add to List Dialog** After typing something in the textfiled and if the “Ask Insert” is selected this dialog pops up and asks the user if he want to save the actual typed entry.

8.4.2 Settings

This sub tab sheet is used to specify the oil test cell and the liquid test cell. The settings are important for the relative permittivity and DC resistivity calculation.





In the field “Quantity” you define how many liquid test cells you will use (the maximum are 10 liquid test cells). For all liquid test cells you have to set the “File Name” (either you make a new file or you open an existing file, see 8.3 File Manager), the “Serial No.”, the capacitance of the empty test cell (C Air), the temperature of the empty test cell, and the calibration date.

You can use the sequence “Test Cell Calibration” for an automatic determination of the C Air , the Temperature and the date. The heat up will also be done automatically.

The “C_{air}” is used for the calculation of relative permittivity and the DC resistivity.

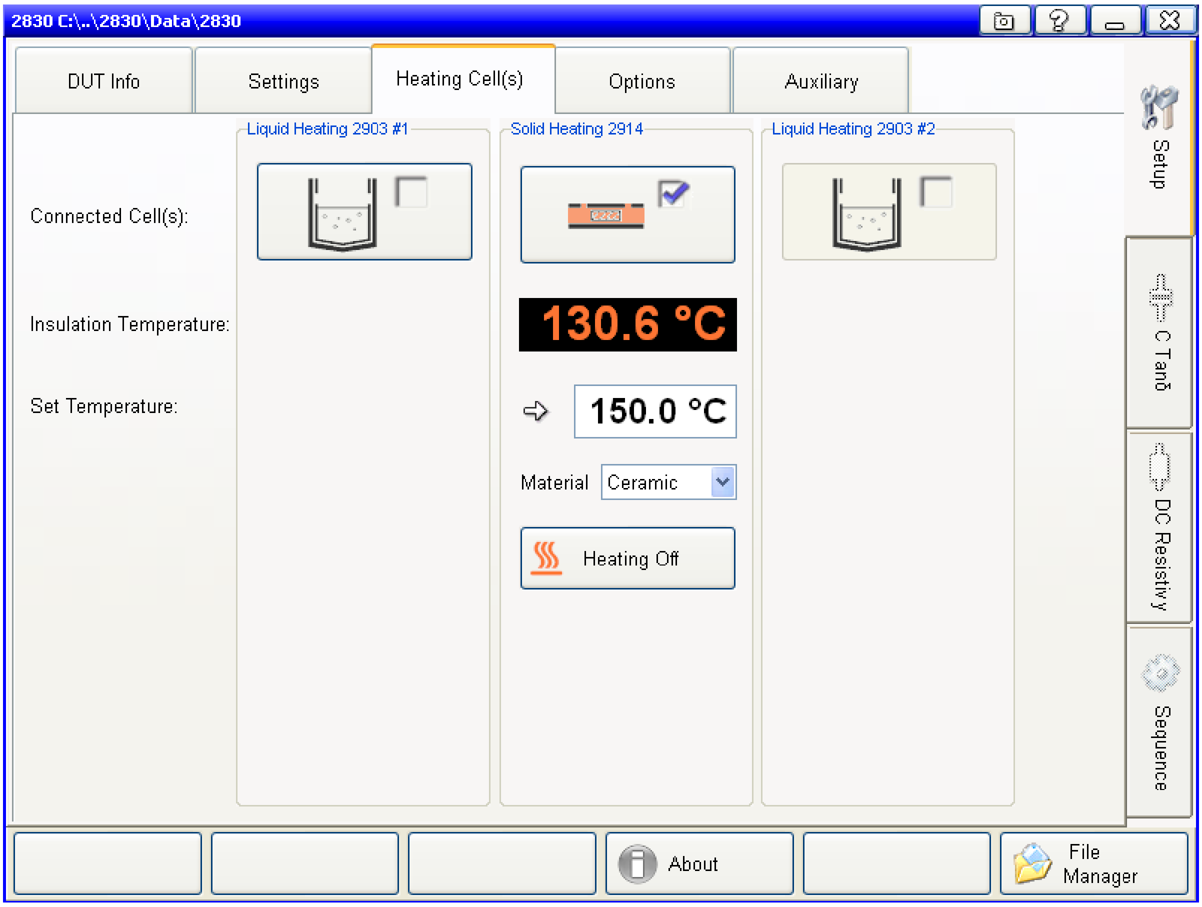
The plate distance in cm (generally the thickness of the solid sample) is used for the calculation of relative permittivity and the DC resistivity.

The thickness of the solid sample has to be measured manually.

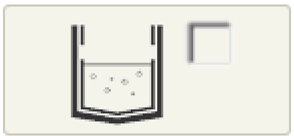
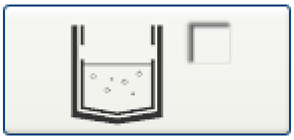
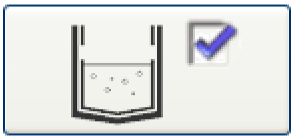
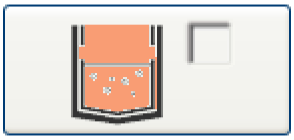
8.4.3 Heating Cell(s)

This sub tab sheet is used to select the liquid test cell heater or the solid test cell heater. Either one to two liquid test cell heater or one solid test cell heater can be selected at same time.

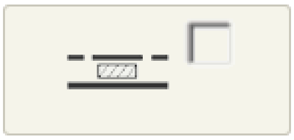
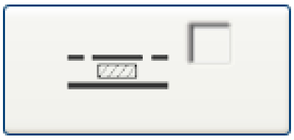
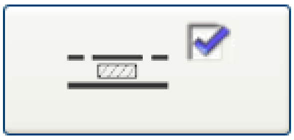
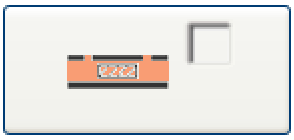
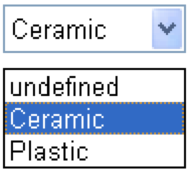
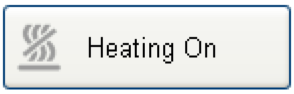
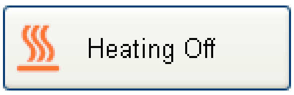
If no test cell is connected to the 2831 then no heater can be selected. If two liquid heaters are connected then the solid test cell heater can not be selected.



The liquid heaters can have following states:

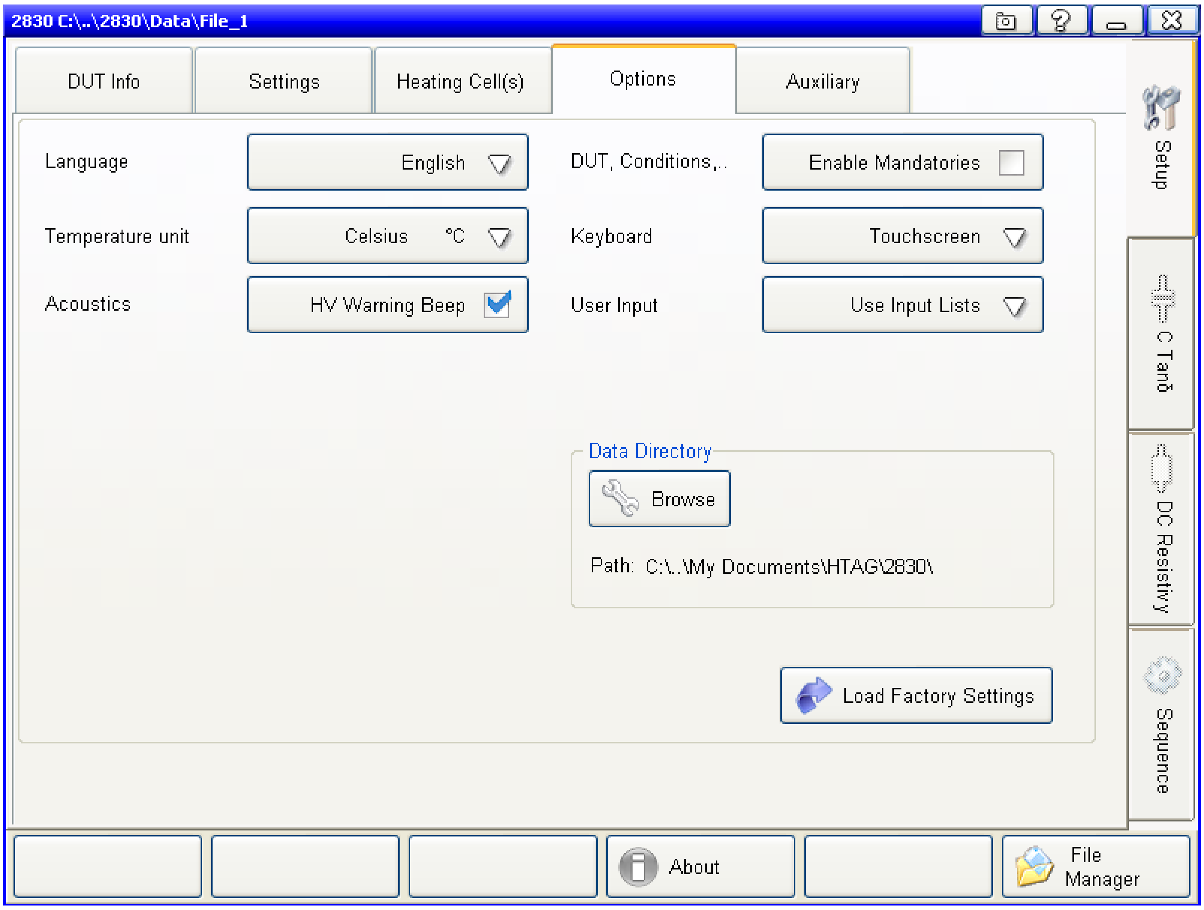
	**Disabled Liquid Heater** If no heater is connected to the 2831 then the heater button is disabled.
	**Enabled Liquid Heater** The heater button is enabled when a heater is connected to the 2831.
	**Selected Liquid Heater** To select a heater click on the accordant heater button. If it is selected then the checkbox is checked.
	**Hot Liquid Heater** When the liquid test cell is hotter than 45° C then the test cell symbol will be red.

The solid heater can have following states:

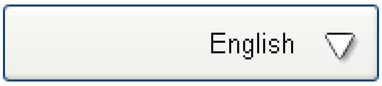
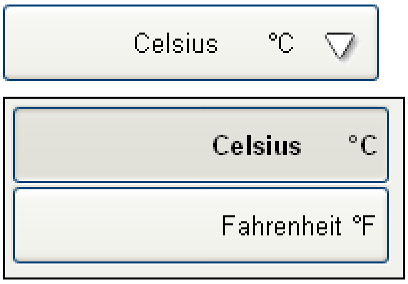
	**Disabled Solid Heater** If no heater is connected to the 2831 then the heater button is disabled.
	**Enabled Solid Heater** The heater button is enabled either when a solid test cell is connected to the Solid Heating port or one liquid heater is connected to the Liquid Heater #1 port.
	**Selected Solid Heater** To select a heater click on the accordant heater button. If it is selected then the checkbox is checked.
	**Hot Solid Heater** When the solid test cell is hotter than 45° C then the test cell symbol will be red.
	**Insulating Temperature** The value indicate the actual temperature of the insulating material
	**Set Temperature** The target temperature on which the insulating material will be heated up
	**Material** When the solid test cell is selected, the solid material can also be selected if well-known.
	**Heating On** The heater On/Off button looks like this when the heater is switched off. Click on the button to switch the heater on.
	**Heating Off** The heater On/Off button looks like this when the heater is switched on. Click on the button to switch the heater off.

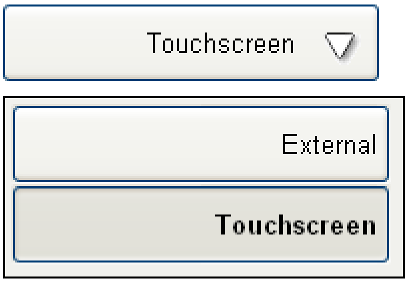
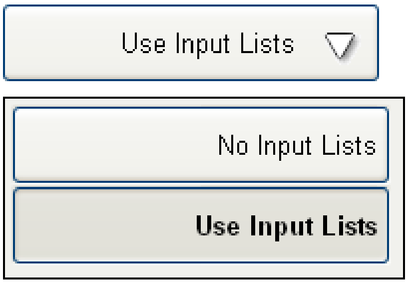
8.4.4 Options

On this sub tab sheet several options can be set.



Following options can be set:

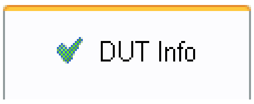
	**Language** Select the operating language. At the moment only English is supported. Please contact our sales department for further languages.
	**Temperature Unit** Here you can select the unit for temperature, if you choose “Celsius °C” the unit meter “m” will be automatically used for lengths. If “Fahrenheit °F” is selected the unit feet “ft” will be used.
	**Acoustics** An acoustic sound will be audible when either the AC or DC HV will be switched and this option is selected.
	**Enable Mandatory** If this option is activated certain inputs in Menu Setup has to be filled before the measuring can be started. See chapter 8.4.4.1 Mandatory Inputs

	**Keyboard** If the option "Touchscreen" is selected then a dialog with a software keyboard will pop up when on a text field is clicked. If the option "External" is selected no dialog pops up and an external connected keyboard has to be used. For numerical inputs the engineering unit like kilo, nano a.s.o. can be set by pressing 'G' Giga 'M'. Mega 'k' Kilo 'm' milli 'u' mikro 'n' nano 'p' pico after the number. The Unit like Volt will be automatically added.
	**User Input** In the sub tab sheet "DUT Info" and "Auxiliary" you can use a entry selection list which stores all your made entries. "No Input Lists" disables the entry selection list and "Use Input Lists" enables it. See chapter 8.4.1.1 Touch Screen Keyboard.
	**Data Directory** With this button the data directory can be selected. All reports will be stored in the subfolder "Data" in the selected directory.
	**Load Factory Settings** After leaving the factory or after a recalibration, the values of standard capacitor, cable length, temperature channels are tested and stored. By clicking this button you will be asked, if you want to use these settings.

8.4.4.1 Mandatory Inputs

All inputs which are preceded with a red asterisk (✱) are mandatory fields. That means at least one character has to be filled in. This "lock-functionality" can be enabled/disabled in the sub tab sheet 8.4.4 Options.

If there is an mandatory input field which has to be filled in, the tab sheet button at the top is marked with a red asterisk.

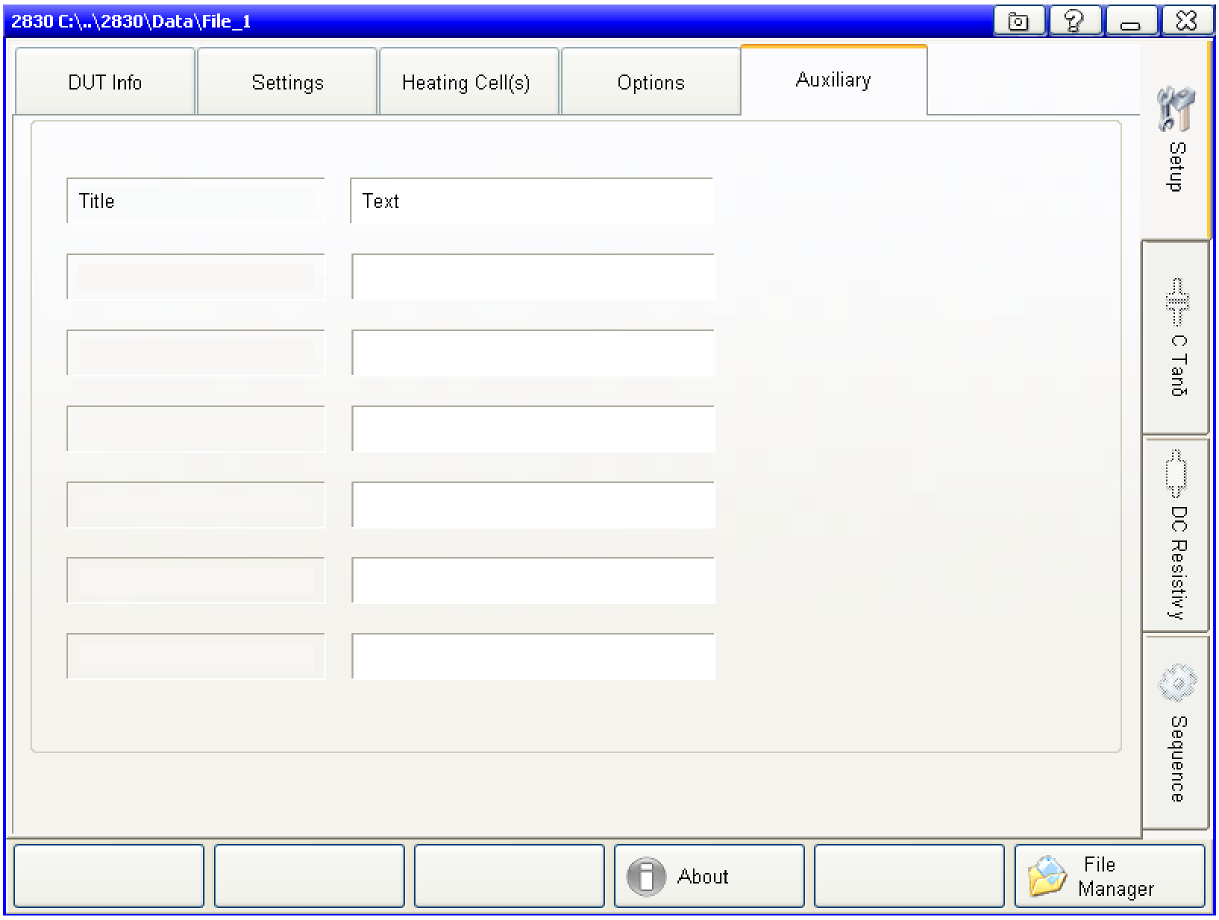


When all marked mandatory fields are filled, the red asterisk in the tab sheet button will switch to a green hook.

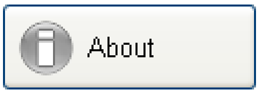
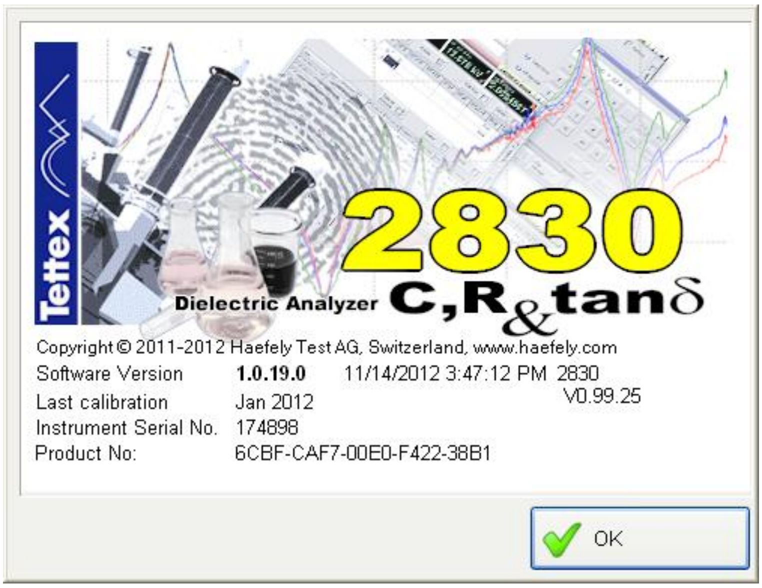
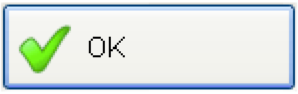
8.4.5 Auxiliary

On this sub tab sheet additional information for the measurement can be filled in. The information will be stored and showed in the report file.

There are two columns of text field. The left columns are for the title and the right ones are for the text.



8.4.6 About Screen

	**About** By clinking on the about button a window will pop up with information of the measuring instrument 2830.
	**About Screen** The about screen shows important information's of the instrument and software. Software Version Firmware Version Last Calibration Instrument Serial No. Product No. This information are important in case of support is need or a upgrade has to be done(see chapter 14 Trouble Shooting).
	**OK** By clicking on the OK button the About window will be closed.

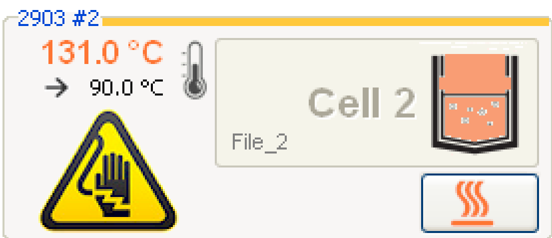
8.5 C Tan δ

The C Tan δ mode is used to perform single measurements straight away. It displays all necessary values at a glance and allows to capture a measurement by a single mouse click.

The following screen shot shows a running measurement on the heater 2903 #2 and liquid test cell 2 as an example. Both heater are heating.

Depending on the made settings in the sub tab sheet “Heating Cell(s)” (see chapter 8.4.3 Heating Cell(s)) it is displayed either one to two liquid heaters or one solid test cell in the heater & cells status section.

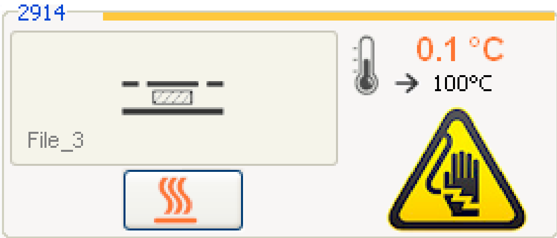
The chapter 8.2.3 Heater & Cell Status describes how a liquid test cell could be assigned to a liquid heater and gives more information about the test cells status. The following liquid and solid heater and cell status field gives a basic description:



Selected Liquid Test Cell

The yellow bar indicates the selected liquid test cell. This cell will be measured.

- Liquid heater #2 is selected and test cell 2 is assigned to it.
- “File_2” is selected for the report and results
- Heating is switched on
- Set temperature is 90°C and the actual temperature is 131.0° C
- Measurement is running (yellow warning symbol)

	**Selected Solid Test Cell** The yellow bar indicates the selection of the solid test cell. This cell will be measured. ▪ Solid heater & test cell are selected. ▪ “File_3” is selected for the report and results ▪ Heating is switched on ▪ Set temperature is 100°C and the actual temperature is 0.1° C ▪ Measurement is running (yellow warning symbol)

The actual measurement values will be displayed in the following measurements displays:

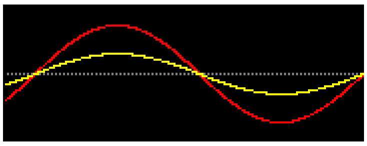
Different font colors are used to identify the actual status and validity:

Dark green	The measured values are not yet stable. The built-in averaging routine is still calculating a mean value. Normally during voltage or frequency changes the values are displayed in dark green.
Light green	The value is now stable and has the correct accuracy. In an automatic sequence mode the value will be recorded now and the next voltage step will be set.
Dark yellow	Signal Overflow error. This case should not be seen during normal operation.

Except the first element (U rms) the other three measurement displays can be customized by clicking the arrow ▼ in the top right corner of the element.

Following measuring values can be selected:

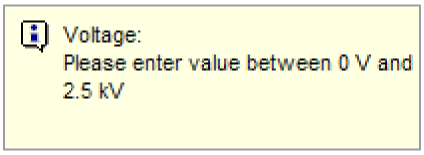
DF (tan δ)	**DF (tan δ)** Actual measured dissipation factor
DF % (tan δ)	**DF%(tan δ)** Actual measured dissipation factor in percentage format
Electrical Stress	**Electrical Stress** Actual measured electrical stress. The electrical stress is depending on the voltage and the gap between the electrodes. The gap for the liquid test cell is hard implemented to 2 mm and for the solid test cell the gap is given in the text field “Plate Distance” in the sub tab sheet “Settings” (see chapter 8.4.2 Settings)
Permittivity	**Permittivity** Actual measured relative permittivity
U rms	**U rms** Effective voltage applied to the test object
Frequency	**Frequency** Measured frequency of applied voltage
In rms	**In rms** Effective current through C_N

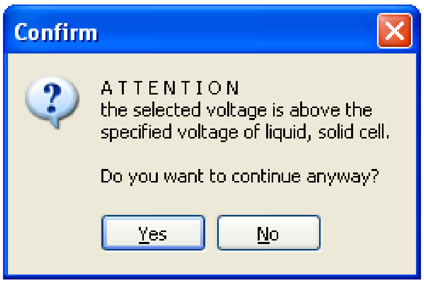
Ix rms	**Ix rms** Effective current through C_X
Cx	**Cx** Value of measured capacitance
Cn	**Cn** Value of standard capacitor
Ambient Temperature	**Ambient Temperature** Actual measured ambient temperature.
Insulation Temperature	**Insulation Temperature** Actual measured insulation temperature in the test cell.
Relative Humidity	**Relative Humidity** Actual measured relative humidity.
Scope 	**Scope** Selecting “Scope” the applied signal will be displayed on the right side of the display. Red signal => Current through C_N (Ref. Signal) Yellow signal => Current through C_X

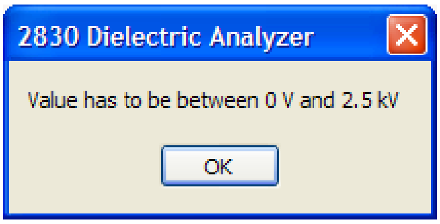
The middle section of the tab sheet C Tan δ contains:

Sample 1	**Sample Identifier** Each time when the record button is clicked the text inside this text field will be copied into the “Sample” column. It is recommended to label the sample with an identifier such as “Sample 1”, “Sample 2” etc. It can also be left blank.
50.0 Hz Frequency: Please enter value between 40.0 Hz and 65.0 Hz 2830 Dielectric Analyzer Value has to be between 40.0 Hz and 65.0 Hz OK	**Set Frequency** In this text field the AC test voltage can be set. If the option “Touch screen” is set in the sub tab sheet Options (see 8.4.4 Options) a frequency input dialog will be opened. The info text on the right side will be displayed where the range of the settable frequency is specified. If the option “external” is selected then no voltage input dialog will be opened. The voltage can be typed directly into the text field. If a frequency out of range is set this info message will pop up.

<table>
<tr>
<td>





</td>
<td>
Set Voltage

In this text field the AC test voltage can be set.

If the option “Touch screen” is set in the sub tab sheet Options (see 8.4.4 Options) a voltage input dialog will be opened. The info text on the right side will be displayed where the range of the settable voltage is specified.

If the option “external” is selected then no voltage input dialog will be opened. The voltage can be typed directly into the text field.

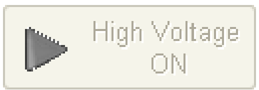
If a voltage higher than 2 kV is set then a warning message will pop up because the maximal AC voltage for the liquid and solid Tettex test cells is 2 kV.

If a voltage out of range is set this info message will pop up.
</td>
</tr>
<tr>
<td>

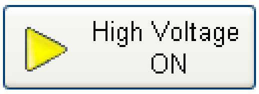

</td>
<td>
Record

The actual selection of measured data will be stored in the spreadsheet.
</td>
</tr>
</table>

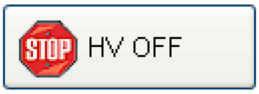
Only the following three states of the HV ON/OFF button are described here. The other buttons are descried in the chapter 8.2.4 Basic Buttons

<table>
<tr>
<td>


</td>
<td>
HV Disabled

When the HV ON/OFF Button is disabled then no heater or test cell is selected, the emergency button is pressed, one of the interlock connectors are not connected or another measurement is running.
</td>
</tr>
<tr>
<td>


</td>
<td>
HV ON

This button state is used to switch ON the set voltage.
</td>
</tr>
<tr>
<td>


</td>
<td>
HV OFF

This button state is used to switch OFF the set voltage.
</td>
</tr>
</table>

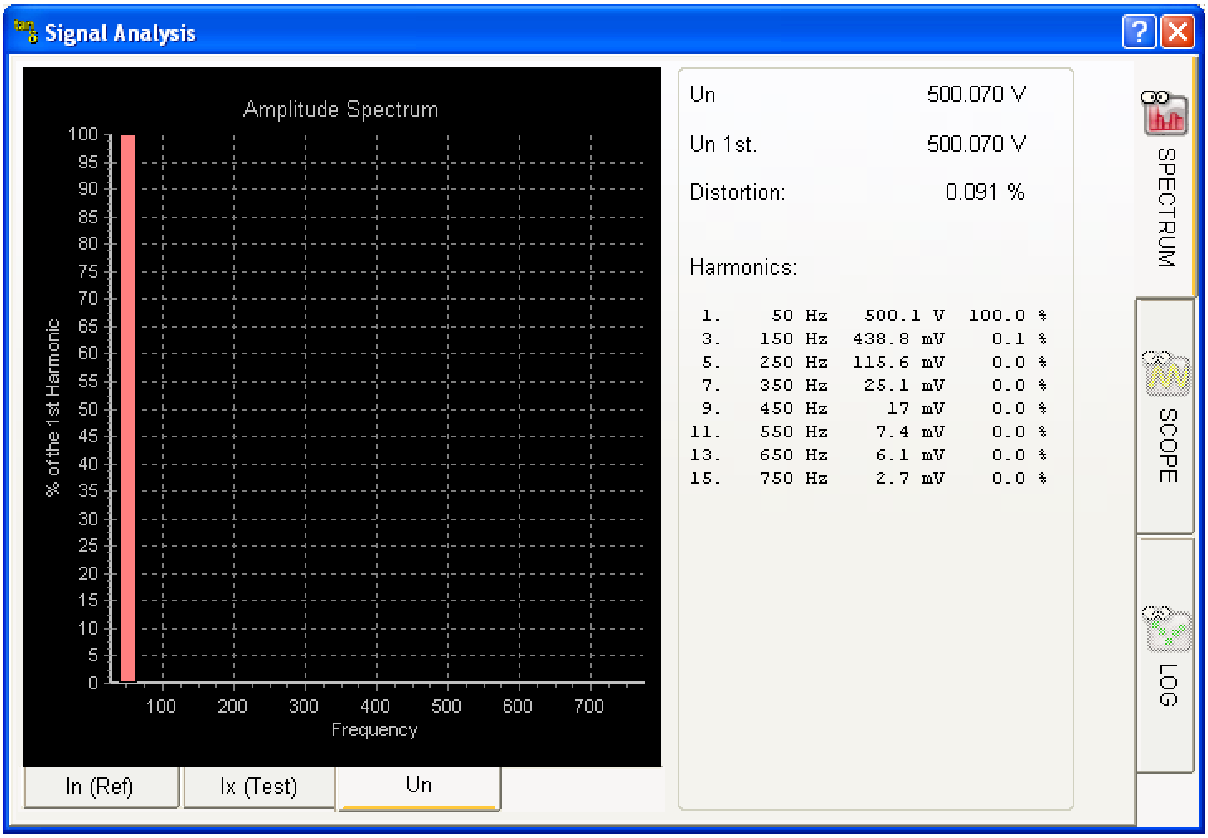
8.5.1 Signal Analysis

If you need more information about the signal wave shape and the spectrum of the measured signal you can use this menu. It is only for information purpose and has no importance for analyzing the test object.

8.5.1.1 Spectrum

This tab sheet will show you the spectrum of the measured signals. The amplitudes are related to the amplitude of the first harmonic in percent %.

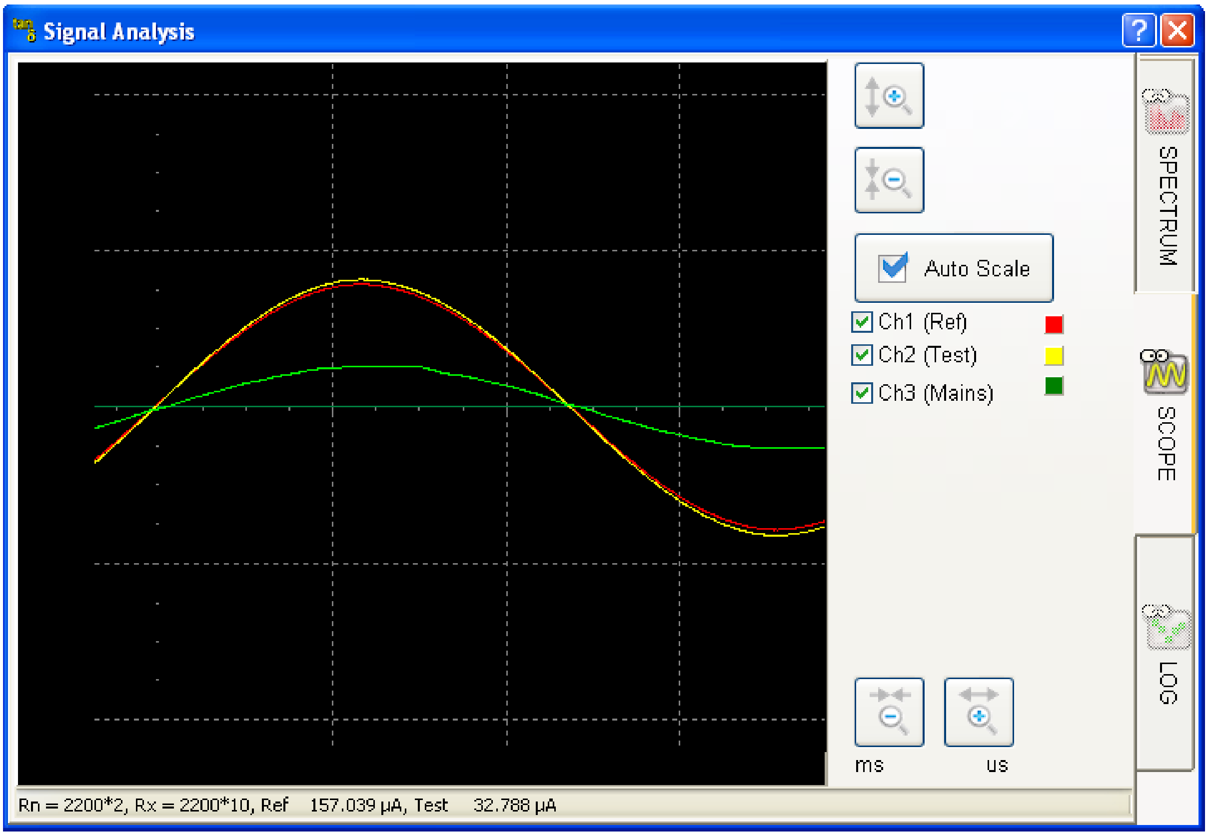
The first 15 harmonics are shown.



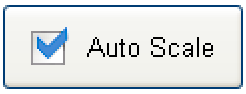
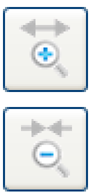
In (Ref)	**In** If this Tab Sheet is selected you can see the spectrum of the current through the nominal standard capacitor
Ix (Test)	**Ix** If this Tab Sheet is selected you can see the spectrum of the current through the test object
Un	**Un** The Spectrum of the integrated In(Ref) signal will be shown. This corresponds to the applied test voltage.

8.5.1.2 Scope

With this tab sheet you will get an impression of the real data, which is recorded by the Analogue Digital Converter (ADC). The amplitude of the signal corresponds with the degree of modulation of the ADC, where 2^{23} (8388608) is the maximum of modulation. The X – Axis shows the number of recorded samples. The Sampling rate is 48 kHz, it corresponds with the time, where the unit 1 is 20.83 µs.

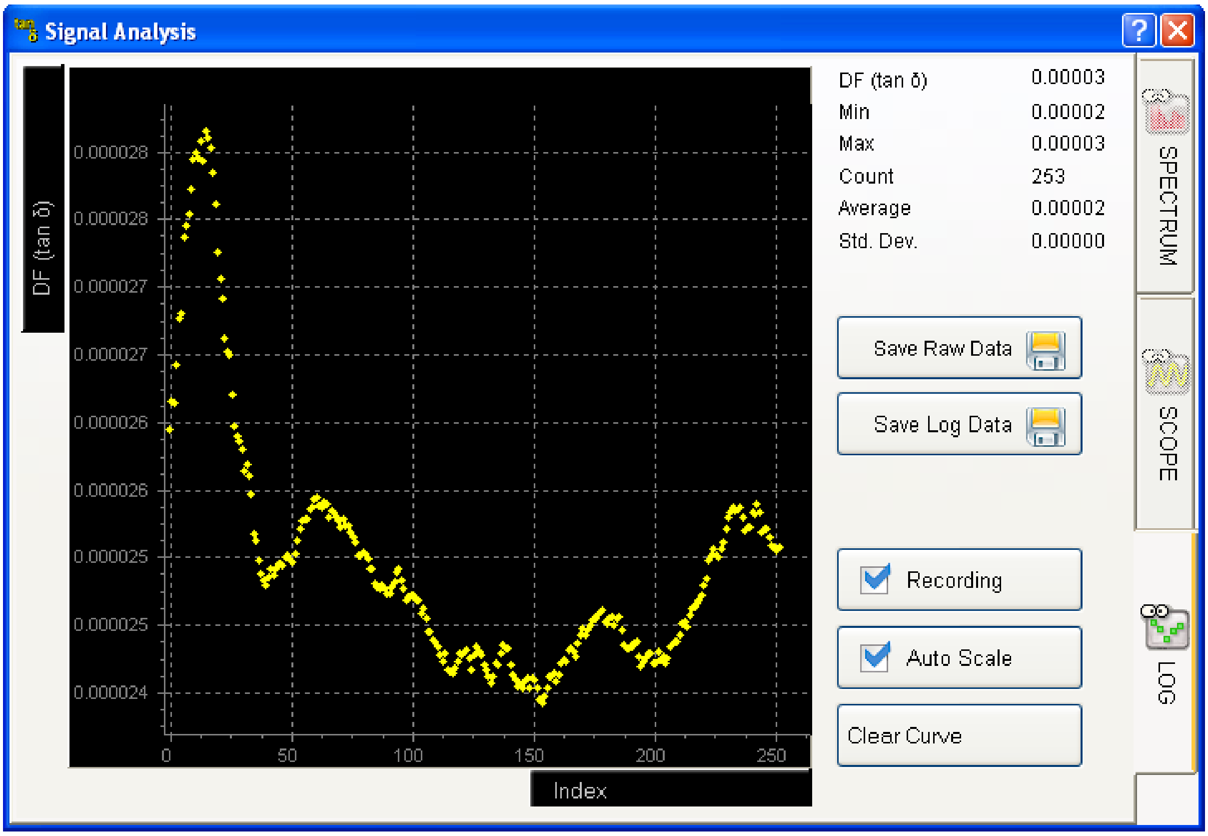


Button description:

	**Up / Down Amplitude** With Up, the signal amplitude is shown larger. The Auto Scale button will be automatically disabled. With Down, the signal amplitude is shown smaller, this increases the scale.
	**Auto Scale** Setting this option will show the signal well scaled.
Ch1 (Ref)	The voltage over the nominal standard capacitor will be shown
Ch2 (Test)	The voltage over the test object will be shown
Ch3 (Mains)	The mains input voltage will be shown
	**Inc / Dec Time Base** By pressing "ms" Button, the time scale will increased. As a result, there are more recorded data visible. By Pressing "µs" Button, the time scale will be decreased. As a result, there are less data will be shown.

8.5.1.3 Log

This menu records all measured data in function of the time. It displays some statistical data as average and standard deviation. Be aware that the recorded data looks very instable. This is caused by the automatic scaling of the scope, where the lowest and the highest value will be used for minimum and maximum y-axis. At maximum 1000 values are recorded.



Buttons description:

DF (tan δ) Index	**X / Y Axis** The measuring values for the x- or y-axis can be chosen.
Clear Curve	**Clear Curve** Clear recorded values.
Auto Scale	**Auto Scale** Enable/disable automatic scaling of the scope. If it is unchecked higher and lower values than the maximum range of the scope are not shown anymore
Recording	**Recording** If this option is deactivated, the recording of the measuring values will be stopped.
Save Raw Data	**Save Raw Data** Store recorded raw data of the ADC. Filename can be selected. The data are stored as CSV format (Comma Separated Values). Should only be used for debugging purpose.
Save Log Data	**Save Log Data** Pressing this button will save the logged measurement values as displayed in the scope at the left side.

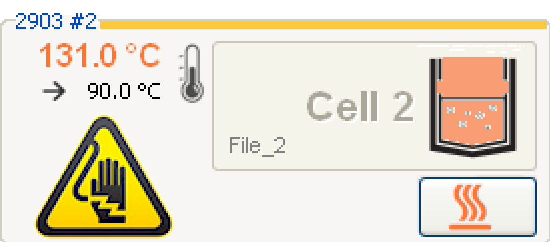
8.6 DC Resistivity

The DC Resistivity mode is used to perform single measurements straight away. It displays all necessary values at a glance and allows to capture a measurement by a single mouse click. According the standard the liquid test cell should be shorted (see the following chapter 8.6.1 Test Cell Shorting) before carry out the DC Resistivity measurement when a C Tan δ measurement was done before.

The following screen shot shows a running measurement on the heater 2903 #2 and liquid test cell 2 as an example. Both heater are heating.

Depending on the made settings in the sub tab sheet Heating Cell(s) (see chapter 8.4.3 Heating Cell(s)) it is displayed either one to two liquid heaters or one solid test cell in the heater & cells status section.

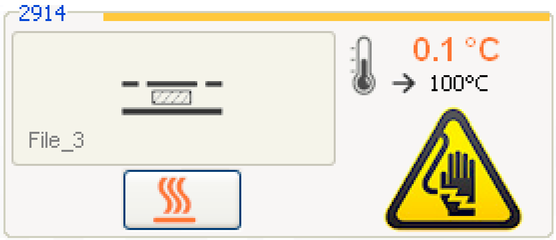
The chapter 8.2.3 Heater & Cell Status describes how a liquid test cell could be assigned to a liquid heater and gives more information about the test cells status. The following liquid and solid heater and cell status field gives a basic description:



Selected Liquid Test Cell

The yellow bar indicates the selected liquid test cell. This cell will be measured.

- Liquid heater #2 is selected and test cell 2 is assigned to it.
- “File_2” is selected for the report and results
- Heating is switched on
- Set temperature is 90°C and the actual temperature is 131.0° C
- Measurement is running (yellow warning symbol)



Selected Solid Test Cell

The yellow bar indicates the selection of the solid test cell. This cell will be measured.

- Solid heater & test cell are selected.
- “File_3” is selected for the report and results
- Heating is switched on
- Set temperature is 100°C and the actual temperature is 0.1° C
- Measurement is running (yellow warning symbol)

After starting the DC Resistivity measurement every 2 seconds a measuring value will be displayed in the following measurement value section. Each of this values will also be stored in the result table. After the usual set measuring time of 1 minute (according to the standards) the measurement will automatically stops and the DUT will be discharged. The last value after 1 minute is the result of the DC Resistivity measurement.

In the measurement value section the actual applied DC voltage, the DC Current, the Resistivity, the Ambient Temperature and the relative Humidity are displayed. The last measured values will not be cleared until a new DC Resistivity measurement starts or a shorting phase is started.

The middle section of the tab sheet DC Resistivity contains:

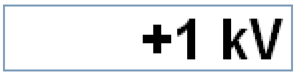
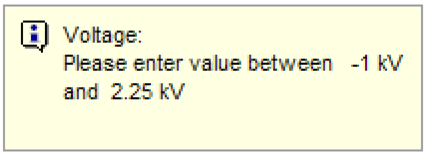
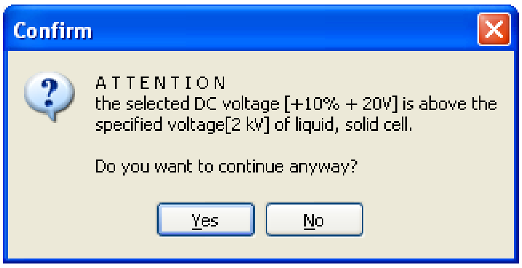
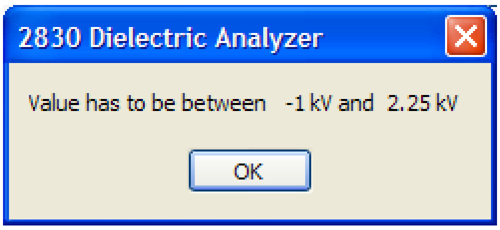
Sample Identifier

Each time when a value is recorded the text inside this text field will be copied into the “Sample” column.

It is recommended to label the sample with an identifier such as “Sample 1”, “Sample 2” etc. It can also be left blank.

Measuring Time

After pressing the Start Test button, the measuring time starts to count down. Measuring results will be recorded every 2 seconds automatically. When the counter is lapsed then the measurement will stop.

 	**Set Voltage** In this text field the DC test voltage and the polarity can be set. Positive polarity: The “U” socket on the front panel is connected to the DC HV and the “a” socket is connected to ground. Negative polarity: The “U” socket on the front panel is connected to ground and the “a” socket is connected to the DC HV.
 	If the option “Touch screen” is set in the sub tab sheet Options (see 8.4.4 Options) a voltage input dialog will be opened. The info text on the right side will be displayed where the range of the settable voltage is specified. If the option “external” is selected then no voltage input dialog will be opened. The voltage can be typed directly into the text field.
 	If a positive voltage higher than 1.8 kV (with the accuracy of +10% + 20V @ 1.8 kV = max. 2 kV) is set then a warning message will pop up because the maximal positive voltage for the liquid and solid Tettex test cells is 2 kV. The maximal negative voltage is - 1kV.
 	If a voltage out of range is set this info message will pop up.

Only the following three states of the Start/Stop Test button are described here. The other buttons are descried in the chapter 8.2.4 Basic Buttons.

 	**Disabled Test** When the Start Test Button is disabled then no heater or test cell is selected, the emergency button is pressed, one of the interlock connectors are not connected, another measurement is running or the DC Resistivity measuring unit is not ready.
 	**Start Test** This button state is used to start the measurement.
 	**Stop Test** This button state is used to stop the measurement, before the count down is finished.

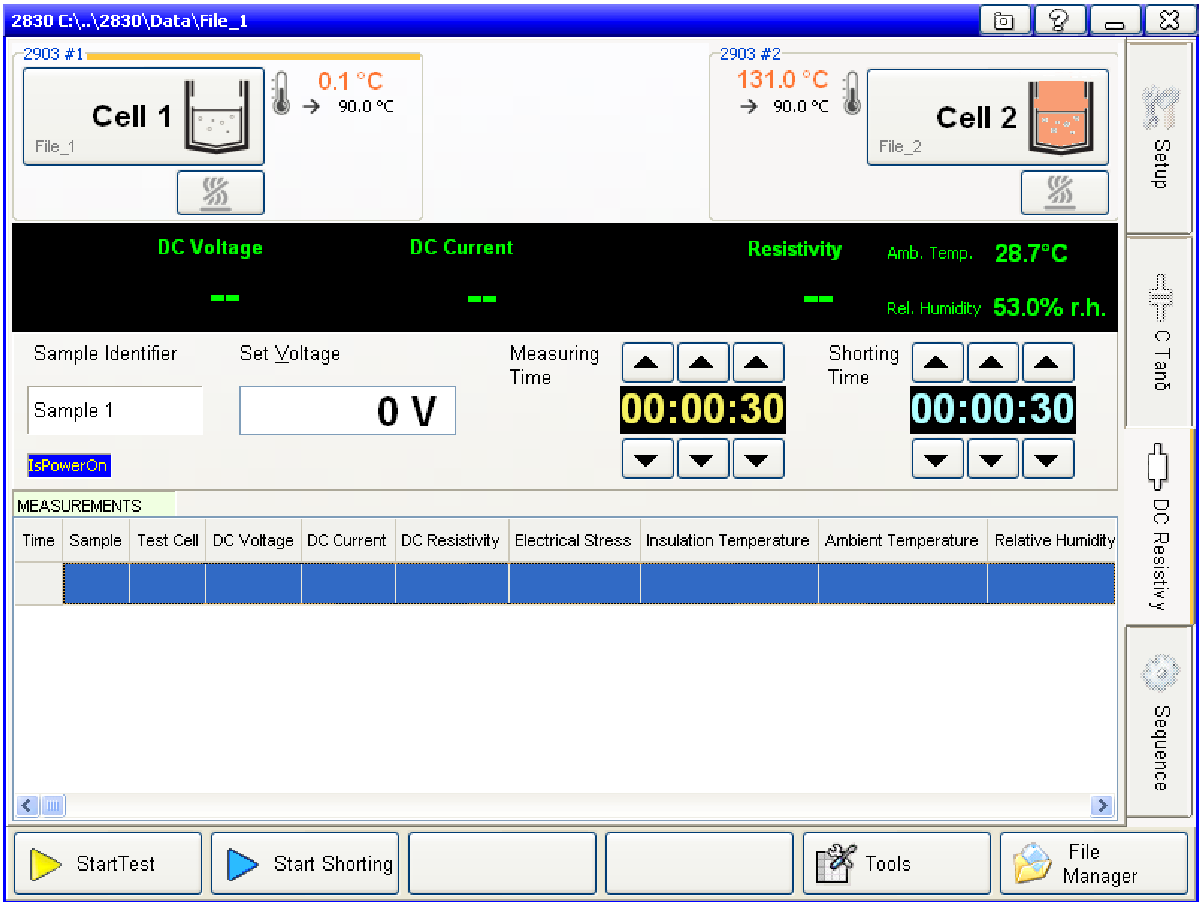
The status labels of the DC Resistivity measuring unit have following meaning:

SetPowerOn	**Set Power On** After starting up the 2830 software a power on command will be sent to the DC Resistivity measuring unit. Before the first DC resistivity measurement will be done it has to be started up.
WaitPowerOn..	**Wait Power On** During power up phase.
WaitCalibrated..	**Wait Calibrated** After powering up a calibration will be done.
CheckCalibration..	**Check Calibration** Validate the calibration.
IsPowerOn	**Power On** The unit is started up.
Measure..	**Measure** During a measurement.
Set Stop	**Set Stop** A stop command is sent to break the actual running measurement.
Wait Stopped..	**Wait Stopped** Wait until the stop command was executed.
Measure Cancelled	**Measure Cancelled** When a measurement was not done completely, “Measure Cancelled” will be labeled.

8.6.1 Test Cell Shorting

As mentioned in the chapter 8.6 DC Resistivity the liquid test cell should be shorted before a DC Resistivity measurement is done after a C Tan δ measurement.

The shorting is also done in the DC Resistivity tab sheet but no voltage and measuring time has to be set only the blue shorting time has to be set. During the shorting phase the “U” and “a” plug on the front panel is shorted.



During the shorting procedure, except the actual ambient temperature and the relative humidity, no results will be displayed in the measurement value section.

Shorting related elements:

	**Disabled Shorting** When the start shorting button is disabled then no heater or test cell is selected, the emergency button is pressed, one of the interlock connectors are not connected or another measurement is running.
	**Start Shorting** This button state is used to start the shorting.
	**Stop Shorting** This button state is used to stop the shorting, before the count down is finished.
	**Shorting Time** After pressing the start shorting button, the shorting time starts to count down. When the counter is lapsed the shorting will stop.

8.7 Sequence

With a sequence a entire measurement process as it is defined in the standards or according to customer specifications can be automated. All manual activities like the heating and measurement processes can be programmed with a sequence and executed automatically. A sequence can be used either with one to two liquid test cells or one solid test cell.

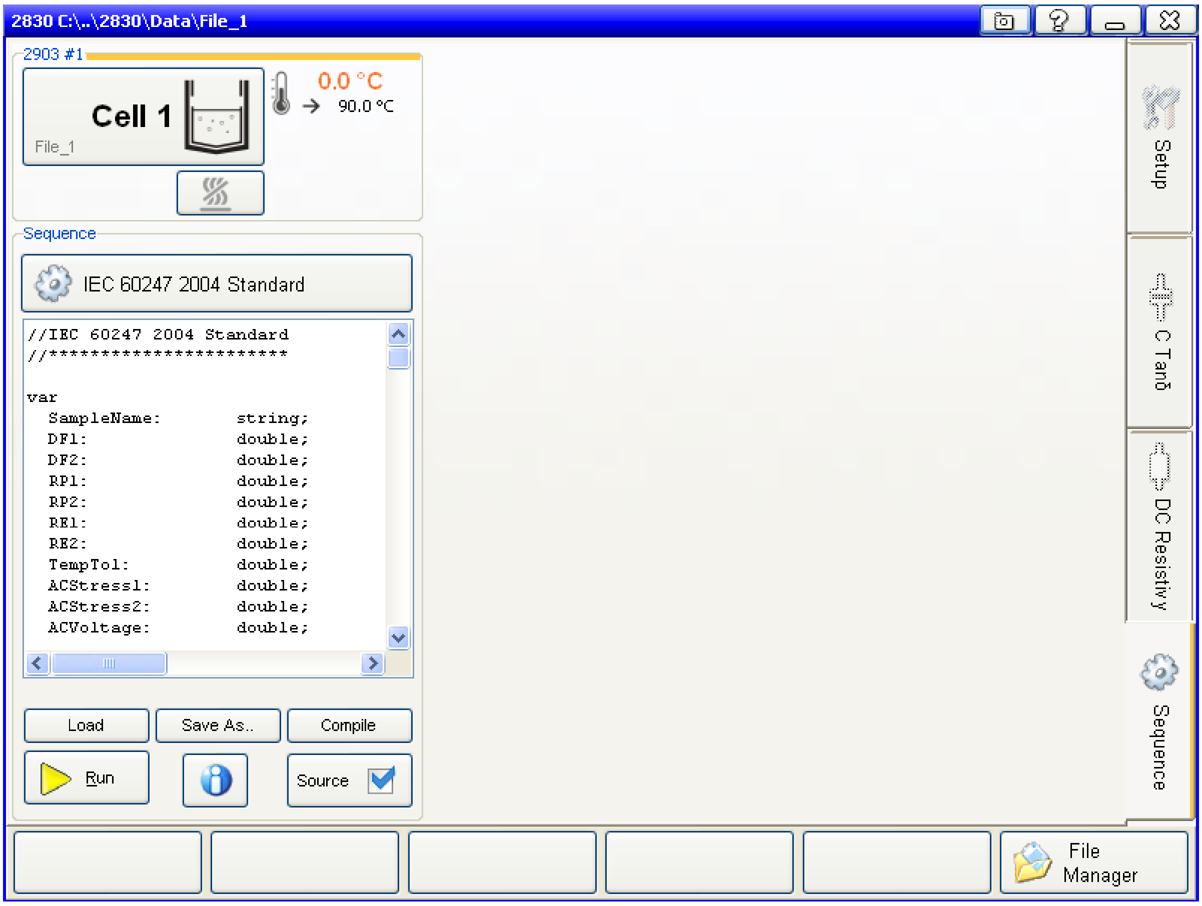
Several sequences according to the IEC, ASTM, VDE, BS, SAC standards (referee and routine procedures) for liquid insulating materials are pre installed. Additional a calibration sequence is installed which heats up and measures the empty liquid test cell and copies the measurement result Cair, the test cell temperature and the calibration date in the cell settings table (see chapter 8.4.2 Settings).

In the "Sequence" folder which is located in the data directory (see chapter 8.4.4 Options) are block diagrams of the pre installed sequences process as PDF file.

8.7.1 Run a Sequence

On the tab sheet Sequence sequences can be selected, programmed and started/stopped. As for the C Tan δ and DC Resistivity measurements a heater and a test cell has to be selected. (see chapter 8.4.3 Heating Cell(s) and 8.2.3 Heater & Cell Status).

On the following screen shot is an example with one selected liquid test cells.



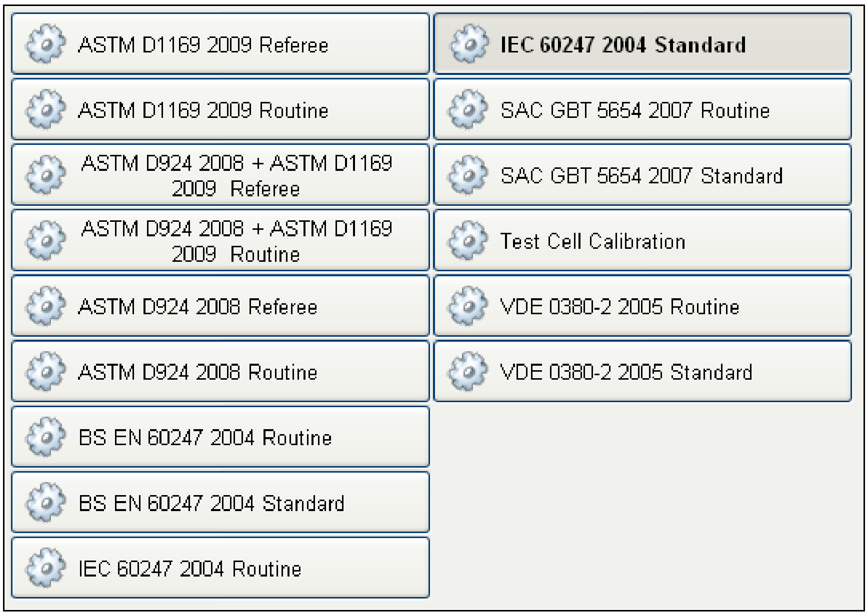
To select and start a sequence following steps has to be done:

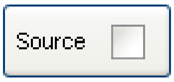
Select a Sequence

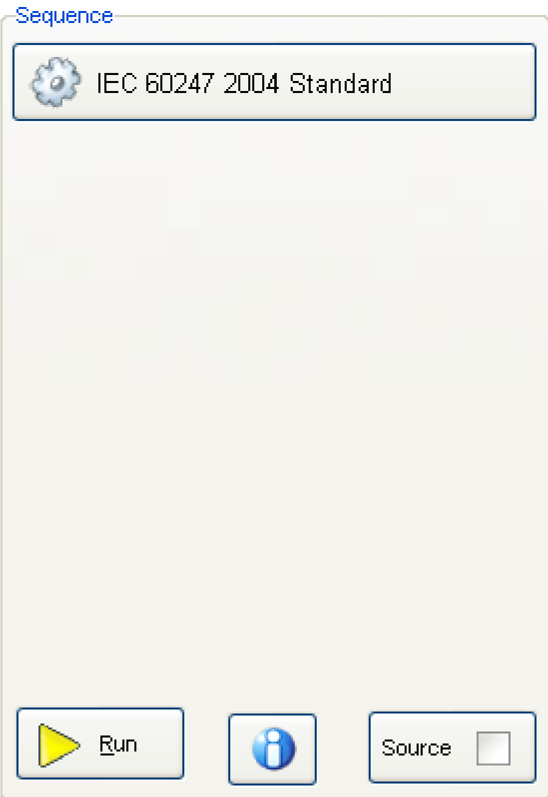
Click on the sequence list button and a sequence list will open with the pre installed sequences and if own sequences were made then they will also be listed.

Sequence List

In the sequence list all sequences which are found in the Sequence folder (file ends with *.seq) will be listed



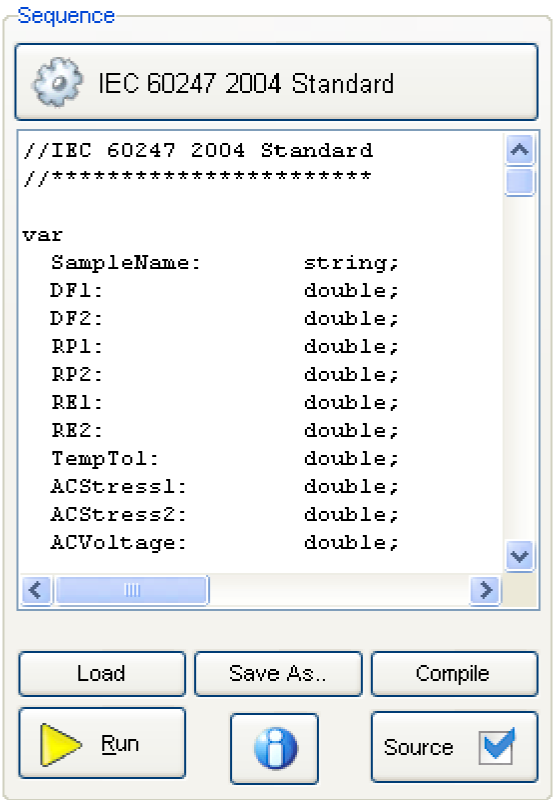


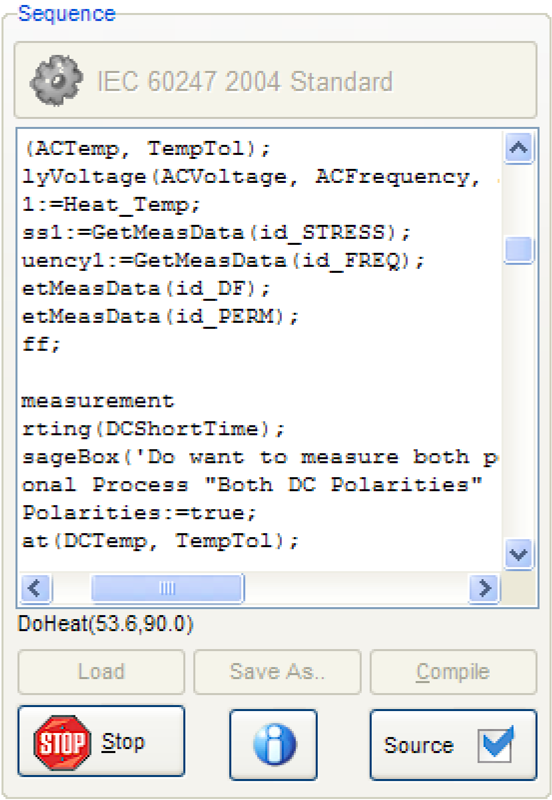


Source Disabled

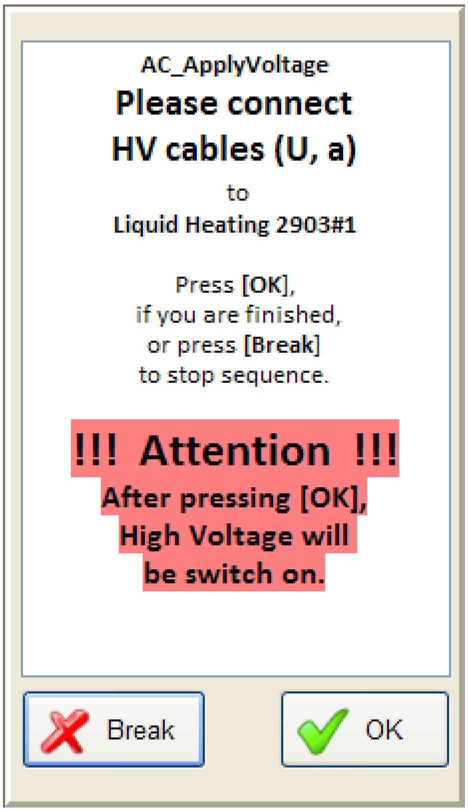
By unchecking the checkbox on the Source button no source code is displayed.

Tettex

 	**Source Enabled** By checking the checkbox on the Source button a text field will be displayed with the source code of the selected sequence
	**Disabled Run** When no heater is selected or no liquid test cell is assigned then the HV On/Off button is disabled and the sequence can not be started.
	**Run** By clicking on the Run button the sequence starts.

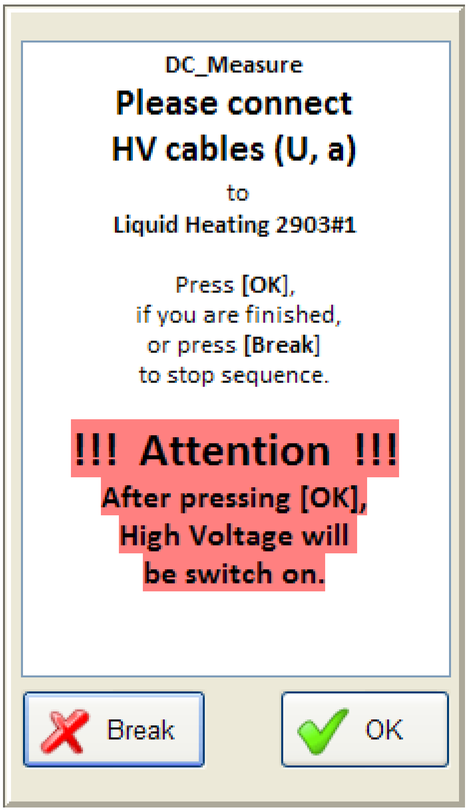
	**Running Sequence** After starting the sequence the source selection, the Load, the Save As and the Compile button are disabled. Below the source code text field the actual command is displayed.
	**Stop Sequence** By clicking on the Stop button the sequence ends.

Before a sequence apply AC/DC voltage or short the test cell a dialog pops up to warn and inform the user which test cell and heater has to be connected to the 2831. On the dialogs is a Break button to abort the sequence without applying any voltage and a OK button to confirm the correct test cell connection and the HV warning.



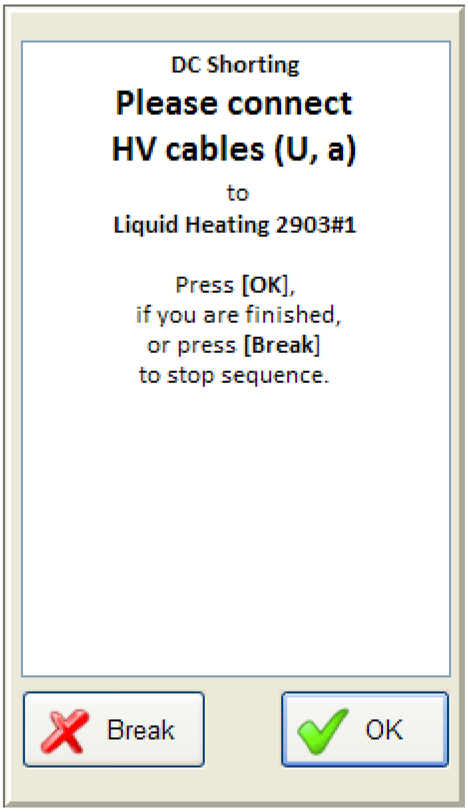
AC Voltage Dialog

Before the AC HV source will generate AC voltage a warning dialog appears.



DC Voltage Dialog

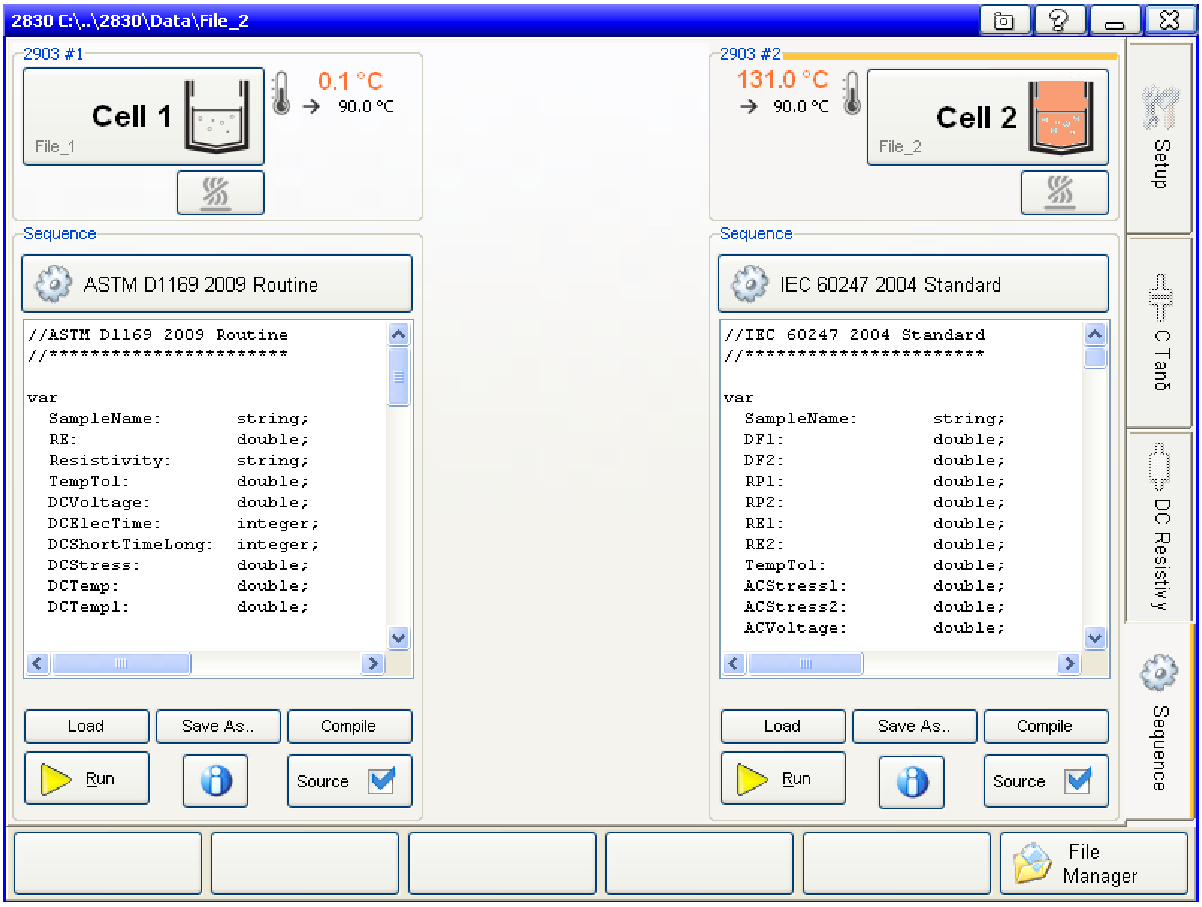
Before the DC HV source will generate DC voltage a warning dialog appears.

	**AC Voltage Dialog** Before the shorting between the “U” and “a” sockets on the front panel will be made a information dialog appears.

8.7.2 Run two sequences simultaneously

For a high routine measurement throughput two liquid sequences can be running at the same time. The heat up can be done independently at the same time for two liquid cells. A measurement can only be made on one cell simultaneously because only one measuring channel is available.

On the following screen shot is an example with two selected liquid test cells and heaters.



After selecting the heaters, test cells and standards both procedures can be started. (see chapter 8.7.1 Run a Sequence). To find the optimum combination of sequences and start time delay between them regarding the throughput it has to be done several tests because it depends on different factors such as cleaning and preparation time of each sample, the number of test cells that are available etc.

8.7.3 Program a Sequence

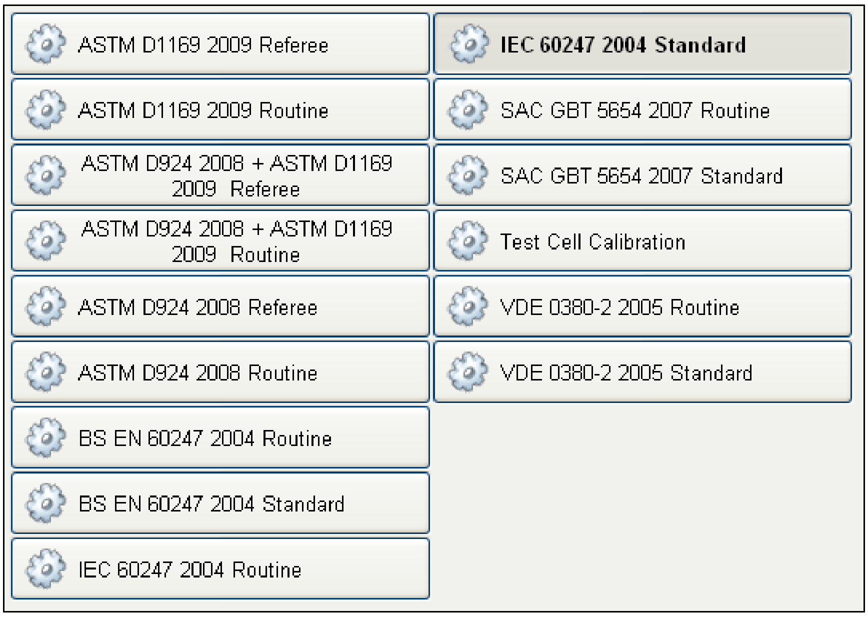
The user has the possibility to program his own sequences with a pseudo code. The commands which can be used and a code sample are described in the chapter 8.7.5 Sequence Commands.

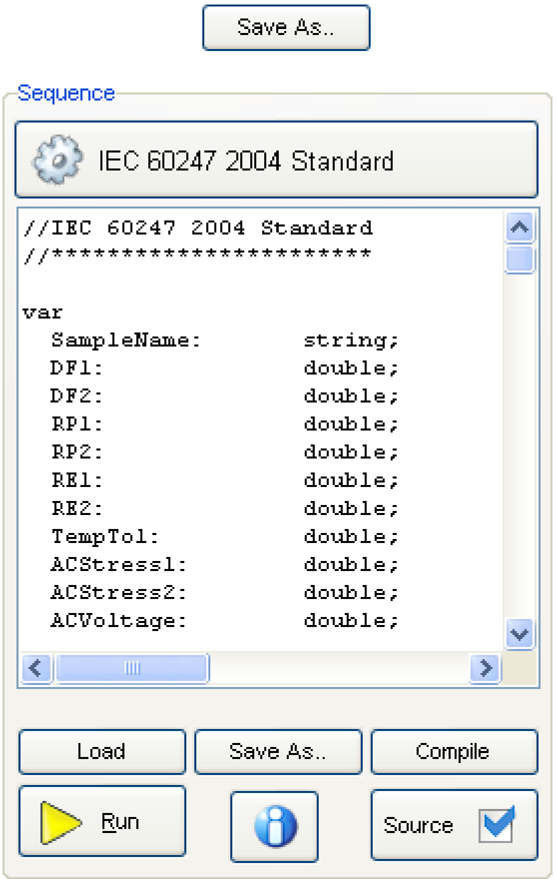
Before a user specific sequence will be programmed the specification and expectation of the measurement has to be known. Basically following specifications should be defined.

- Type of measurement (liquid or solid)
- Heating temperature
- Kind of measurement
- Test voltage
- Measurement process
- Measurement values
- What to report

The easiest way to program a new sequence is to open a existing one to rename it and then to edit it. To edit the sequence a standard text editor can be used or write direct in to the source code text field. After programming the sequence it has to be stored in the liquid or solid subfolder of the path “data directory\Sequence” with the file ending “*.seq”. When the path and/or the file ending is not correct then the programmed sequence will net be displayed in the sequence list.

The following table describes a possibility to edit a sequence from a existing one:

Open a existing sequence e.g. IEC 60247 2004 Standard


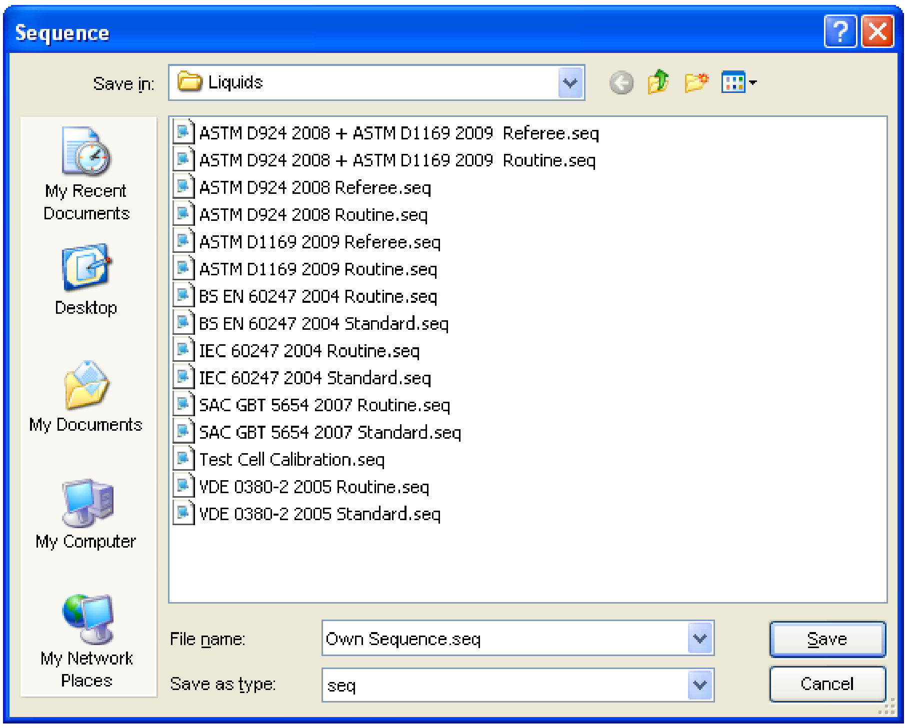


Save As

Use the button “Save As” to rename the sequence and to store it in the following folder: For liquid sequences: ..\Data directory\Sequence\Liquids and for solid sequences: ..\Data directory\Sequence\Solids.

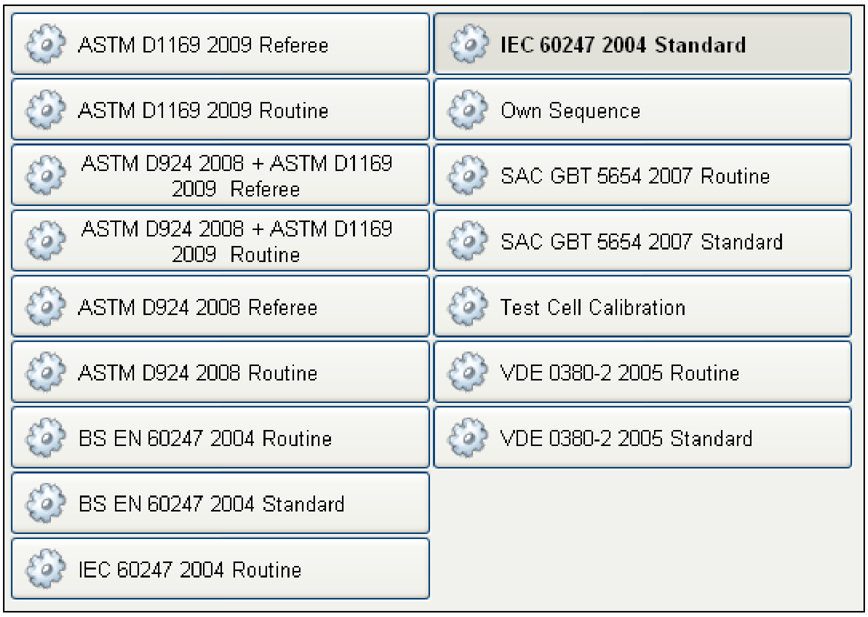
The data directory can be defined in the sub tab sheet Options (see chapter 8.4.4 Options)

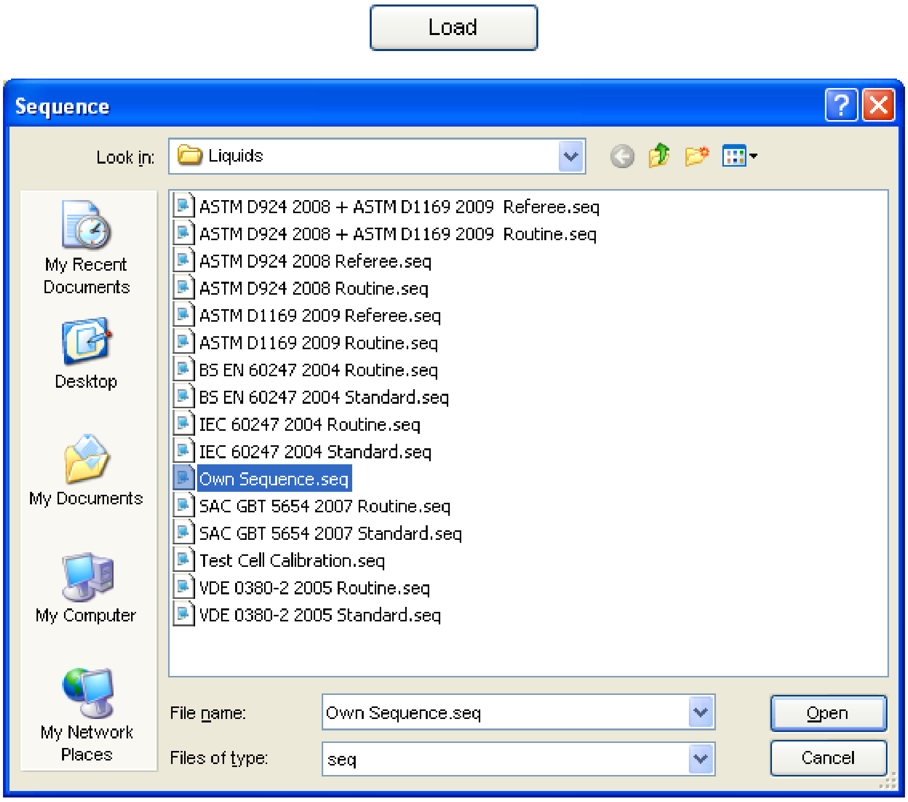
Rename the new sequence e.g. **Own Sequence.seq** and save it.

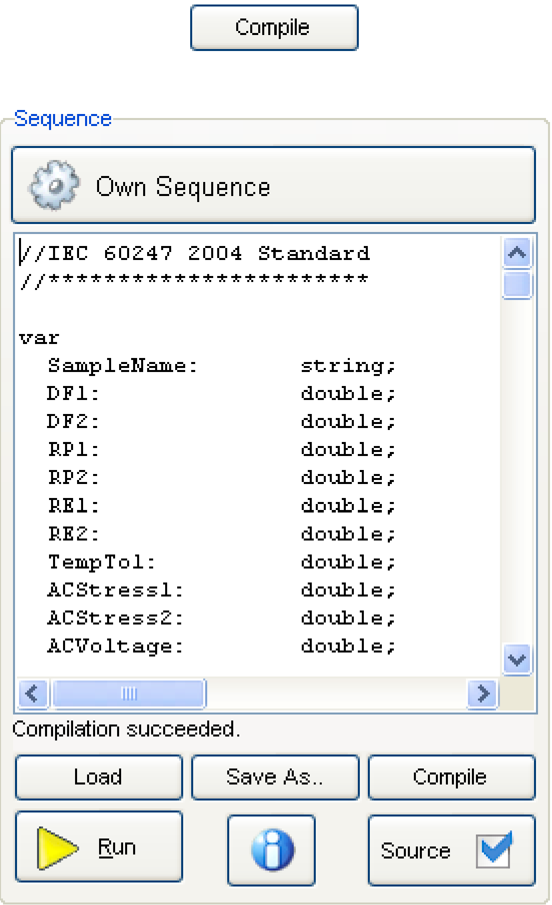


Load

Load the renamed sequence by pressing the new sequence button Own Sequence in the sequence list or the Load button.





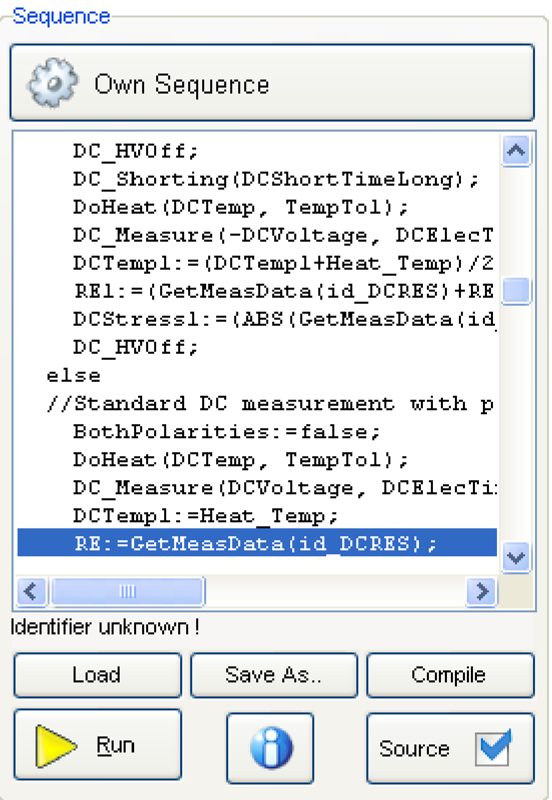


Compile
The sequence can now be edited.

The sequence can be edited direct in the source code text field or with an other text edit software e.g. Notepad. Using a mouse and keyboard to edit the sequence on the instrument make the work easier.

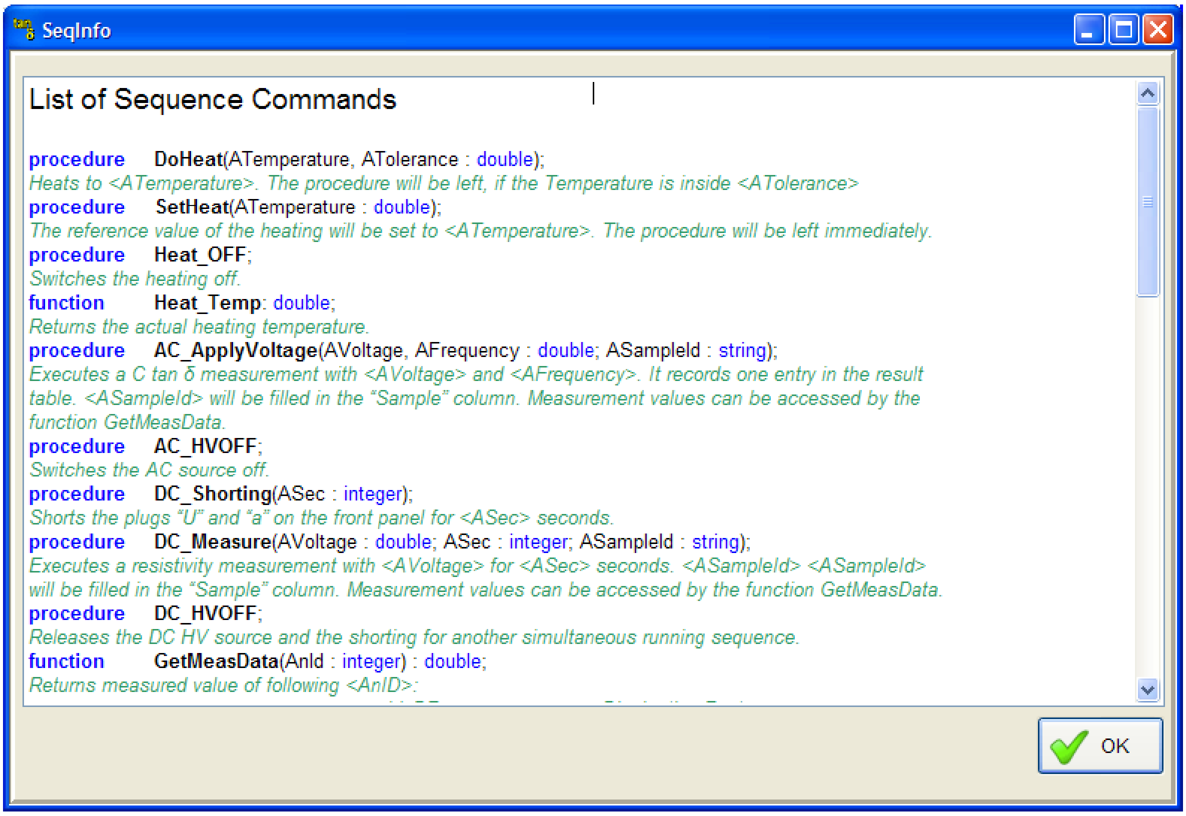
The USB-Mouse and USB-Keyboard can be connected in the USB sockets on the front panel of the 2830.

Use the Compile button to check if the sequence is programmed correctly. If the program source code has no errors then the message “Compilation succeeded” appears and the source code will be saved automatically.



In case of an error in the in the program source code, the compiler will stop at the wrong line and a error message appears.

Info
By clicking on the Info button a window will pop up with a short description of the usable sequence programming commands. More detailed command description can be found in the chapter 8.7.5 Sequence Commands.



8.7.4

8.7.5 Sequence Commands

We distinguish between seven different terms for programming the sequence. Each of this terms is described in a separate sub chapter. If a own sequence has to be programmed then it is recommended to read through these sub chapters and a existing sequence source code.

- Sequence Structure
- Variables
- Fix Variables
- Operators
- Procedure
- Function
- Flow Control

Each command has to be finished by a semicolon " ; " except the keywords "`var`", "`begin`" and "`end.`".

Comments in the code are possible by adding two slashes " `\\` " at the end of a code line or on a empty line. For testing and debugging a sequence the comments are very helpful to comment out code lines to ignore them.

There is no difference between upper and lower case letters in the source code.

8.7.5.1 Sequence Structure

A sequence code has following code structure:

```
var
       VariableS:    string;
       VariableI:    integer;
       VariableD:    double;
       VariableB:    boolean;
       …
```

Declaration of Variables

The keyword is `var` for the first sequence code section. If no variables has to be defined then this section can be omitted.

```
procedure UserProcedure(A,B: double);
begin
       VariableD:=A+B;
end;
```

Declaration of User Procedures

For complex sequences the user can define his own procedures for a better legibility and for repetitive command sets.

```
function UserFunction(A,B: integer): boolean;
begin
       if A>B then
              UserFunction:=true;
       else
              UserFunction:=false;
       end;
end;
```

Declaration of User Functions

For complex sequences the user can define his own functions for a better legibility and for repetitive command sets.

```
begin
       VariableI:= 5;
       CommandC;
       UserProcedure(2.52,2);
       CommandD;
       VariableB:=UserFunction(VariableI,10);
       …
```

Start of Sequence

A sequence will execute all commands after the keyword `begin`.

```
end.
```

End of Sequence

A sequence will execute all commands up to the keyword `end.`. Every code after this keyword will be ignored.

A sequence code must contain at least the keywords `begin` and `end.` to be executable.

8.7.5.2 Variable

Variables can be defined by the user. The name of a variable can not be the same as a command or a fix variable and must begin with a letter.

Following data types can be used for variables:

Integer	A whole number in the range: -2,147,483,648 to 2,147,483,647
Double	A fraction number in the range: 15 significant digits, exponent -308 to +308
String	A text with the maximal number of 255 ASCI characters.
Boolean	True or false

8.7.5.3 Fix Variable

The following three variables are reserved and can only be used for the described application. They can be accessed like a variable of the string data type.

CellCAir	Read and write the air capacitance C air of the actual selected test cell. Correspond to the column "C air" on the sub tab sheet Settings (see chapter 8.4.2 Settings).
CellTemp	Read and write the temperature when C air was calibrated of the actual selected test cell. Correspond to the column "@Temperature" of the sub tab sheet Settings (see chapter 8.4.2 Settings).
CellCalibrated	Read and write the calibration date and time of the actual selected test cell. Correspond to the column "Calibrated" of the sub tab sheet Settings (see chapter 8.4.2 Settings).

8.7.5.4 Operators

Following operators are used to assign variables, make calculations and program condition expressions.

:= **Assignment**

This operator is used to assign a value to a variable. It is used for each data type.

+ **Addition**

This operator can be used for double, integer and string data types. String variables or terms can be added together

Sample:

```
s:='The result' + 'is' + adddouble(12.5,0,1);
```

- **Subtraction**

This operator can be used for double and integer data types.

***** **Multiplication**

This operator can be used for double and integer data types.

/ **Division**

x / y with y > 0

This operator can be used for double and integer data types.

mod **Modulo**

x mod y with y > 0

This operator gives back the remainder of an integer division.

Samples:

```
11 mod 3      // = 2
9 mod 3       // = 0
x mod 1       // = 0
```

= **Equality**

This operator compare if two value are equal and returns true (equal) or false (not equal). It can be used for integer, double and string data types.

<> **Inequality**

This operator compare if two value are not equal and returns true (not equal) or false (equal). It can be used for integer, double and string data types.

and **Logical and**

This operator can only be used for the boolean data type.

or **Logical or**

This operator can only be used for the boolean data type.

not **Logical not**

This operator can only be used for the boolean data type.

< **Less than**

x < y

Check if x is less than y. This operator can be used for integer or double data types. Returns true or false.

<= **Less than or equal**

x <= y

Check if x is less than y or equal. This operator can be used for integer or double data types. Returns true or false.

> **Greater than**

x > y

Check if x is greater than y. This operator can be used for integer or double data types. Returns true or false.

>= **Greater than or equal**

x >= y

Check if x is greater than y or equal. This operator can be used for integer or double data types. Returns true or false.

8.7.5.5 *Procedure*

A procedure is a set of commands which will be executed. A procedure can be called with additional variables or a values in brackets e.g. a text, a number etc. A procedure executes the command set and returns no value.

ShowMessage(AMessage: String);

Shows a message box with <AMessage> as text and an OK button. The routine waits until the OK button in the message box will be clicked on.

Sample:

```
var
       AMessage:     string;
       …
begin
       AMessage:='Your Text';
       ShowMessage(AMessage);
       …
end.
```

ReportClear;

Clears the section "TestResults" in the report file. Create the Report by starting with this command.

ReportAdd(AResult: String);

Adds a text for the section "TestResults" in the report file. The <AResult> string is limited to a length of 255 characters. If more text is to add then the `ReportAdd` command can be used again until the whole text is added. By adding the "+CRLF" to the <AResult> string a new line is inserted into the string.

Sample:

```
       …
       ReportAdd('Standard: ASTM xxxx'+CRLF);
       …
```

ShowReport;

The internet browser will open and the test report will be displayed.

Wait(ASec: Integer);

Wait the time <ASec> in seconds until the next command will be execute.

Sample:

```
       …
       Wait(20);
       …
```

DoHeat(ATemperature, ATolerance: Double);

Switch the heater controller ON and heat up the test cell to the defined temperature <ATemperature>. The procedure will be left if the temperature is inside the defined ± tolerance <ATolerance>.

In the following sample the heater will be switched ON and the target temperature 90 °C is set. The sequence will wait at the `DoHeat` command until 89° C is reached, then the sequence will go on. The temperature is controlled furthermore to 90° C until the `Heat_OFF` command will be sent.

Sample:

```
var
       Temp:          double;
       TempTol:       double;
       …
begin
       Temp:=90;
       TempTol:=1;
       DoHeat(Temp, TempTol);
       …
       Heat_OFF;
end.
```

SetHeat(ATemperature: Double);

Switch the heater controller ON and begins to heat up the test cell to the defined temperature <ATemperature>. The procedure will left without reach the defined temperature and controls the temperature furthermore until the `Heat_OFF` command will be sent. This command only make sense in combination with the `Wait` command.

Sample:

```
var
       Temp:  double;
       …
begin
       Temp:=90;
       SetHeat(Temp);
       Wait(1800);
       …
       Heat_OFF;
end.
```

Heat_OFF;

Switch the heater controller OFF.

AC_ApplyVoltage(AVoltage, AFrequency: Double; ASample: String);

This procedure applies the AC test voltage <AVoltage> with the test frequency <AFrequency> and it executs a C Tan δ measurement (see chapter 8.5 C Tan δ). A sample name <ASample> can be set for the measurement which will be filled in the "Sample" column of the result table. Before the test voltage will be applied a dialog pops up with an OK and a Break button (see chapter 8.7.1 Run a Sequence). The user has to click on the OK button to go on. If the Break button is clicked on the sequence will be stopped and no voltage will be applied.

After the test voltage is applied and the measurement is stable all measured values will be stored in the table. The measurement results can be accessed in a sequence by the function `GetMeasData`. To switch OFF the AC test voltage use the `AC_HVOff` procedure.

Sample:

```
var
       ACVoltage:    double;
       ACFrequency:  double;
       DF:           double;
       SampleName:   string;
       …
begin
       ACVoltage:=2000
       ACFrequency:=50
       SampleName:='Oil Sample XX';
       AC_ApplyVoltage(ACVoltage, ACFrequency, SampleName);
       DF:=GetMeasData(id_DF);
       AC_HVOff;
       …
end.
```

AC_HVOff;

Switch the AC power supply OFF.

DC_Measure(AVoltage: Double; ASec: Integer; ASample: String);

This procedure applies the DC voltage <AVoltage> for the time <ASec> time in seconds and it executes a DC Resistivity measurement (see chapter 8.6 DC Resisitivity). A sample name <ASample> can be set for the measurement which will be filled in the "Sample" column of the result table. Before the test voltage will be applied a dialog pops up with an OK and a Break button (see chapter 8.7.1 Run a Sequence). The user has to click on the OK button to go on. If the Break button is clicked on the sequence will be stopped and no voltage will be applied.

During the measurement each 2 seconds a measurement will be stored into the table. When the measurement is done after the set measuring time then the results can be accessed in a sequence by the function `GetMeasData`.

To release the DC HV source for another simultaneous running sequence (see chapter 8.7.2 Run two sequences simultaneously) use the `DC_HVOff` procedure. It is recommended always to use the `DC_HVOff` procedure after a DC Resistivity measurement.

Sample:

```
var
      DCVoltage:    double;
      DCTime :      integer;
      RE:           double;
      SampleName:   string;
      …
begin
      DCVoltage:=200
      DCTime:=60
      SampleName:='Oil Sample XXX';
      DC_Measure(DCVoltage, DCTime, SampleName);
      RE:=GetMeasData(id_DCRES);
      DC_HVOff;
      …
end.
```

DC_Shorting(ASec: Integer);

This procedure shorts the plugs "U" and "a" for the time <ASec> (see chapter 8.6.1 Test Cell Shorting).

To release the shorting for another simultaneous running sequence (see chapter 8.7.2 Run two sequences simultaneously) use the `DC_HVOff` procedure. It is recommended always to use the `DC_HVOff` procedure after the shorting.

Sample:

```
var
      DCShortingTime:     integer;
      …
begin
      DCShortingTime:=300;
      DC_Shorting(DCShortingTime);
      DC_HVOff;
      …
end.
```

DC_HVOff;

Release the DC HV Source and the shorting for another simultaneous running sequence. It is recommended always to use this procedure after a `DC_Measurement` or a `DC_Shorting` procedure.

Sound(AFrequency, ALength: Integer);

Generate sound with the frequency <AFrequency> and the length <ALength>. The speaker is the internal buzzer in the 2830.

UserProcedure(Value1, …, ValueN: Datatype; ValueA, …, ValueX: Datatype);

The user has the possibility to program is own procedures e.g. for a often used command sequence. The declaration of the user procedure has to be made before the keyword `begin`.

Sample:

```
var
      Variable_Text:      string;
      Variable_Int:       integer;

procedure procedureA(A,B: integer; S: string);
begin
      ShowMessage(S+AddDouble(A+B,0,0));
end;

procedure procedureB;
begin
      ShowMessage('Some Text');
end;

begin
      Variable_Text:= 'Some Text';
      Variable_Int:=10;
      procedureA(Variable_Int-5, Variable_Int+5, Variable_Text);
      procedureB;
end.
```

8.7.5.6 Function

A function is a set of commands which will be executed. A function can be called with additional variables or a values in brackets e.g. a text, a number etc. A function executes the command set and returns a value such as the actual heating temperature, a measured value etc.

AddInt(AVal, AAbsLength: Integer): String;

Converts the integer value <AVal> into a string. <AAbsLength> determines the absolute length of the result string. If the absolute length is longer than the value the procedure fills up the missing digits with whitespaces. If it is shorter then the integer number will be cut.

If the <AMinLength> = 0 then the result string will be empty.

Samples:

```
AddInt(12,0);        //''
AddInt(12,1);        //'1'
AddInt(12,2);        //'12'
AddInt(12,4);        //'  12'
```

AddDouble(AVal: Double; AMinLength, ADigits: Integer): String;

Converts the double value (an integer value can also be used) <AVal> into a string. <ADigits> determines the number of significant digits. <AMinLength> determines the minimal length of the result string. If the minimal length is longer than the value the procedure fills up the missing digits with whitespaces.

Samples:

```
AddDouble(1.2345,0,0);     //'1'
AddDouble(1.2345,0,3);     //'1.235'
AddDouble(1.2345,6,4);     //'1.2345'
AddDouble(1.2345,8,4);     //'  1.2345'
```

AddDate: String;

Returns the actual date as a string type.

AddTime: String;

Returns the actual time as a string type.

MessageBox(AMessage: String): Boolean;

Show a message box with the text from <AMessage> and the buttons Break and OK. The sequence waits until the OK button is clicked on by the use or stops if the Break button is clicked on. The returning value of this function is false if the Break button or true if the OK button was clicked on.

Sample:

```
…
if MessageBox('Do you want to continue ?') then
       ShowMessage('Continue');
else
       ShowMessage('Stop');
…
```

Heat_Temp: Double;

Returns the actual heating temperature.

CellSNr: String;

Returns the serial number (see chapter 8.4.2 Settings) of actual selected test cell.

GetMeasData(AnID: Integer): Double;

After a measurement is done the measurement result <AnID> can be read out with this function. Always a `Double` value is returned.

Following <AnID> are available:

```
id_DF        Dissipation Factor
id_PF        Power Factor
id_URMS      applied AC Voltage
id_CAP       measured Capacitance
id_FREQ      applied Frequency
id_PERM      measured Permittivity
id_ACSTRESS  measured   AC Electrical Stress
id_DCSTRESS  measured DC Electrical Stress
id_TEMP      actual ambient Temperature
id_HUM       actual relative Humidity
id_DCVOLT    applied DC Voltage
id_DCCURR    measured DC Current
id_DCRES     measured DC Resistivity
```

Sample:

```
var
      DF:           double;
      Cap:          double;
      ACStress:     double;
      …

begin
      …
      DF:=GetMeasData(id_DF);
      Cap:=GetMeasData(id_CAP);
      ACStress:=GetMeasData(id_ACSTRESS);
      …
end.
```

Mathematical Functions

`Abs(AVal: Double): Double;`

Absolute value

This function calculates the absolute value of <AVal>.

`Sqr(AVal: Double): Double;`

Square

This function calculates the square of <AVal>.

`Sqrt(AVal: Double): Double;`

Square root

This function calculates the square root of <AVal>.
Note: <AVal> may not be < 0.

`Exp(AVal: Double): Double;`

Exponential

This function calculates exponent to the base e.

`Ln(AVal: Double): Double;`

Logarithm

This function calculates the logarithm of <AVal> to the base e.
Note: <AVal> must be > 0.

`Sin(AVal: Double): Double;`

Sine

This function calculates the sine of <AVal>. <AVal> is to be entered in radians.

`Cos(AVal: Double): Double;`

Cosine

This function calculates the cosine of <AVal>. <AVal> is to be entered in radians.

`ArcTan(AVal: Double): Double;`

Arc tan

This function calculates the arc tan of <AVal>. The result is given in radians.

`Int(AVal: Double): Integer;`

Integer

This function discards the fractional part of <AVal> and returns the whole number of <AVal>.

`Odd(AVal: Integer): Boolean;`

Odd

This function specifies whether <AVal> is odd (True) or not (False).

`Round(AVal: Double): Integer;`

Rounding

This function converts <AVal> of the `Double` type into a variable of the `Integer` type by rounding.

`Min(AVal, BVal: Double): Double;`

Minimum

Check which of the two values <AVal> and <BVal> is the less one and return it as the result.

`Max(AVal, BVal: Double): Double;`

Maximum

Check which of the two values <AVal> and <BVal> is the greater one and return it as the result.

UserFunction(Value1, …, ValueN: Datatype; ValueA, …, ValueX: Datatype) : ReturnValueDatatype;

The user has the possibility to program is own functions e.g. for a often used command sequence. The declaration of the user function has to be made before the keyword `begin`. A function can have input parameters like <Value1> … <ValueA> but they have to return a value.

To return a value use the name of the function like a variable and assign the result to it.

Sample:

```
var
      Variable_Text:       string;
      Variable_Int:        integer;

function functionA(A,B: integer): string;
begin
      functionA:=AddInt(A+B,3);
end;

function functionB: string;
begin
      functionB:=AddInt(1,1);
end;

begin
      Variable_Text:= 'Test';
      Variable_Int:=10;
      ShowMessage(Variable_Text+functionA(Variable_Int-5, Variable_Int+5));
      ShowMessage(Variable_Text+functionB);
end.
```

8.7.5.7 *Flow Control*

Flow control commands are used for loops and decisions in a sequence. With this commands more complex sequences can be realized e.g. execute commands depending on a user decision made by a dialog.

IF

If the `<condition>` is true then the commands between `then` and `end;` will be executed.

```
if <condition> then
       <command>
       …
end;
```

Sample:

```
if 2 = 2 then
       ShowMessage('2 = 2');
end;
```

IF / ELSE

If the `<condition>` is true then the commands between `then` and `else` will be executed. If the `<condition>` is false then the commands between `else` and `end;` will be executed.

```
if <condition> then
       <command>
       …
else
       <command>
       …
end;
```

Sample:

```
if odd(2) then
       showMessage('True');
else
       showMessage('False');
end;
```

WHILE

While the `<condition>` is true the commands between `do` and `end;` will be executed. The difference to the `repeat until` command is that the `<condition>` is checked before the commands will be executed.

```
while <condition> do
       <command>
       …
end;
```

Sample:

```
var
       i:     integer;

begin
       i:=0;
       while i < 5 do
              showMessage('i = '+addint(i+1,2));
              i:=i+1;
       end;
end.
```

REPEAT UNTIL

The commands between `repeat` and `until` will be executed until the `<condition>` is true. The difference to the `while` command is that the commands are executed before the `<condition>` is checked.

```
repeat
      <command>
      <command>
      …
until <condition>;
```

Sample:

```
var
      i:     integer;

begin
      i:=0;
      repeat
            showMessage('i = '+addint(i+1,2));
            i:=i+1;
      until i > 4;
end.
```

8.7.5.8 Description of a Sequence Sample

The following sequence sample (Test Cell Calibration.seq) is one of the pre installed sequences used for the liquid test cell calibration. Each sequences has the section "Definition of measurement parameters" where the test parameters can be adapted fast such as the test temperature, voltage, frequency etc.

If a own sequence is programmed it is recommended to copy a pre installed sequence and to adapt it (see chapter 8.7.3 Program a Sequence).

Test Cell Calibration.seq

At the beginning of each pre installed sequence are two comment lines with the name of the actual sequence and an asterisk underline.

```
//Test Cell Calibration
//**********************
```

The next section is the variables declaration whose length varies depending on the number and the kind of test are made. In all pre installed sequences are variables declared what have descriptive labelling such as DF (dissipation factor), RP (relative permittivity) or RE (resistivity) etc. In this sample only one C Tan δ measurement will be made therefore no RE or DC prefix variables are used.

In the "IEC 60247 2004 Standard.seq" almost all variables are listed what are used in the pre installed sequences.

```
var
       Cair:         double;
       DF:           double;
       ACVoltage:    double;
       ACStress:     double;
       ACFrequency:  double;
       ACTemp:       double;
       TempTol:      double;
```

In more complex sequences like the "IEC 60247 2004 Standard.seq" are procedures defined before the keyword `begin` *in the declaration section.*

Direct after the keyword `begin` *are the values assigned to the variables with the measurement parameters. To each of this variables is a description written as comment of the parameter range or the exact value which is specified in the according standard.*

```
begin
//Definition of measurement parameters
ACVoltage:=2000;    //According to the used standard (max. 2000V with
                    //the oil test cell 2903)
ACFrequency:=50;    //According to the used standard (40 Hz - 65 Hz
                    //possible with 2831)
ACTemp:=90;         //According to the used standard  (room temp - max 150°C
                    //with 2903)
TempTol:=0.5;       //According to the used standard
```

Then the measurement sequence is following. In this case an AC measurement (C Tan δ) is programmed without the relative permittivity (RP) because it is not needed for the test cell calibration.

```
//AC measurement
       DoHeat(ACTemp, TempTol);
       AC_ApplyVoltage(ACVoltage, ACFrequency, 'Cell Calib');
       ACTemp:=Heat_Temp;
       ACFrequency:=GetMeasData(id_FREQ);
       ACStress:=GetMeasData(id_ACSTRESS);
       Cair:=GetMeasData(id_CAP);
       DF:=GetMeasData(id_DF);
       AC_HVOff;
       Heat_Off;
```

After the measurement is done a check is made if the values are in a good range. If not a dialog will pop up an inform the user that something with the test cell is not good.

```
//Check if Cair is in a good range
      if Cair < 48e-12 then
      ShowMessage('The capacity value of the empty '+CRLF
             +'and cleaned test cell is too '+CRLF
             +'low: '+AddDouble(Cair*1e12,0,0)+' pF '
             +'(48 pF < C air < 72 pF)'+CRLF+CRLF
             +'Check the test cell for dust, wet'+CRLF
             +'and correct assembling.');
      else
             if Cair > 72e-12 then
             ShowMessage('The capacity value of the empty '+CRLF
                    +'and cleaned test cell is too '+CRLF
                    +'high: '+AddDouble(Cair*1e12,0,0)+' pF '
                    +'(48 pF < C air < 72 pF)'+CRLF+CRLF
                    +'Check the test cell for dust, wet'+CRLF
                    +'and correct assembling.');
      else
```

If the measured values are in a good range the values will be stored in the liquid test cell settings of the selected liquid test cell (see chapter 8.7.5.3 Fix Variable).

```
//Save measurement values
             CellCAir:=AddDouble(Cair,0,13);
             CellCTemp:=AddDouble(ACTemp,0,1);
             CellCalibrated:=AddDate;
```

At the end the measuring result will be added to the "Test Results" section of the report. With the keywords `end.` *the sequence ends.*

```
//Create Report
      ReportClear;
      ReportAdd(
             'Test Cell Calibration'+CRLF+
             'Date - Time: '+AddDate+' -
             '+AddTime+CRLF+CRLF+
             'Cell type: '+CellSNr+CRLF+CRLF);
      ReportAdd(
             'Ambient temperature:
             '+AddDouble(GetMeasData(id_TEMP),0,1)+' °C'+CRLF+
             'Ambient humidity: '+AddDouble(GetMeasData(id_HUM),0,1)+'%'+CRLF+
             'AC electrical stress: '+AddDouble(ACStress,0,0)+
             'V/mm'+CRLF+
             'AC frequency: '+AddDouble(ACFrequency,0,1)+' Hz'+CRLF+
             'Temperature of AC test: '+AddDouble(ACTemp,0,1)+'
             °C'+CRLF+CRLF);
      ReportAdd(
             'Tand of Test Cell: '+AddDouble(DF*100,0,3)+' %'+CRLF+
             'Cair of Test Cell: '+AddDouble(Cair*1e12,0,1)+' pF'+CRLF);
      ShowReport;
             end;
      end;
end.
```

9 Accessories

9.1 Accessories and Options

Order code	Description
4842611	Cable set for existing 2903
4842507	Cable set for existing 2914
0065201	2903A Oil Test Cell
0065001	2903H Oil Test Cell Heating
0139311	2914 Solid Test Cell

10 Care and Maintenance

10.1 Care and Maintenance

The instrument is basically service free, as long as the specified environmental conditions are adhered to. As a result, service and maintenance is restricted to cleaning of the equipment and calibration at intervals stipulated by the application for which the instrument is used.

The insulation of all high voltage cables should be periodically checked for damage. If any damage to the insulation is detected then a new measuring cable should be ordered from HAEFELY TEST AG.

If the instrument is to remain unused for a long time then it is recommended that steps are taken to prevent ingress of dust inside the housing through air circulation (i.e. wrap or pack the instrument).

If the instrument is to be used in extreme environmental conditions (e.g. unclean, oily air with airborne metal or coal dust, high humidity etc.) then it should be protected by building into a suitable housing with forced air filtering or similar suitable protection. If such protective measures cannot be provided, then the instrument should be periodically checked for contamination and promptly cleaned with suitable cleanser when required. This kind of service work is particularly important if high voltages are to be measured and should be performed by an authorised service agent.

10.2 Cleaning the Instrument

The instrument should be cleaned with a lint free cloth, slightly moistened using mild household cleanser, alcohol or spirits. Caustic cleansers and solvents (Tri, Chlorothene, etc.) should definitely be avoided.

In particular, the protective glass of the display should be cleaned from time to time with a soft, moist cloth such as used by opticians.

10.3 Instrument Calibration

When delivered new from the factory, the instrument is calibrated in accordance with the calibration report provided. A periodical calibration of the instrument every two years is recommended.

As the calibration process is fairly extensive, the instrument can only be calibrated and, if necessary, adjusted at HAEFELY TEST AG’s factory. An updated calibration report will then be issued.

10.4 Changing Fuses

Before changing the mains fuse, remove the mains power cord. Fuses should only be replaced with the same type and value.

The type and the value of the fielding fuses is written on the rear panel of each device.

11 Instrument Storage

11.1 Instrument Storage

During day to day use the instruments can be switched off at the mains switches located on the lower right corner of the front panel for the 2830 and on the upper right corner of the front panel for the 2831.

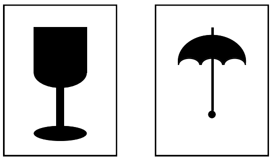
If the instrument is to remain unused for any length of time, it is recommended to unplug the mains lead. In addition, it is advisable to protect this high precision instrument from moisture and accumulation of dust and dirt with a suitable covering.

12 Packing and Transport

12.1 Packing and Transport

The packing of the Measuring instrument provides satisfactory protection for normal transport conditions. Nevertheless, care should be taken when transporting the instrument. If return of the instrument is necessary, and the original packing crate is no longer available, then packing of an equivalent standard or better should be used.

Whenever possible protect the instrument from mechanical damage during transport with padding. Mark the container with the pictogram symbols „Fragile“ and „Protect from moisture“.



Pictograms

13 Recycling

13.1 Recycling

When the instrument reaches the end of its working life it can, if required, be disassembled and recycled. No special instructions are necessary for dismantling.

The instrument is constructed of metal parts (mostly aluminum) and synthetic materials. The various component parts can be separated and recycled, or disposed of in accordance with the associated local rules and regulations.

14 Trouble Shooting

All error messages appear on the display of the measuring instrument. If persistent problems or faulty operation should occur then please contact the Customer Support Department of HAEFELY TEST AG or your local agent.

The Customer Support Department can be reached at the following postal address:

HAEFELY TEST AG

Customer Service - Tettex

Birsstrasse 300

CH-4052 Basel

Switzerland

Tel: +41 61 373 4422

Fax: +41 61 373 4914

e-mail: tettex-support@haefely.com

14.1 Windows Recovery

The 2830 has an integrated PC board and runs on Windows Embedded 7. In case of a damaged Windows operating system (corrupted files, damaged partition etc.) the integrated Windows recovery function can help to restore the instrument in the state it was delivery from the factory.

There are two drives available:
C:/ Contains the Windows installation and all system files
D:/ Contains the user data and installation files of the application software

During the recovery process all files, software, programs, etc. saved on partition C:/ will be deleted.

Any update of the 2830 software that was installed after delivery have to be reinstalled after the recovery process

Follow these steps To recover the instrument to the factory defaults:

1. Switch off the instrument by the main switch on the front panel
2. Connect an external keyboard to one of the USB connectors
3. Switch on the instrument and press the F1 key
4. The instrument starts in the recovery mode and restores Windows
5. The instrument is now reset to factory defaults
6. Reinstall the application software if an update was once done after delivery

14.2 Software Updates 2830

Haefely Test AG runs an Internet Update Homepage where owners of our test instruments can download the newest software, manuals, related information etc:

http://update.haefely.com/ct2830/

Do NOT try to install other “C and tan δ” software or other application on a 2830 hardware or vice versa.

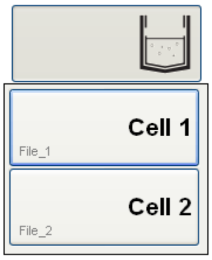
It won’t work at all!

14.3 FAQ

The FAQ (Frequently Asked Questions) chapter contains a collection of questions from users and the correspondent answer which could help to clear the questions.

Q: “The HV ON button is disabled and I am not able to switch the HV on, what could I do ?”

A: Check if the “Reg” and “Temp” cables of the Oil Test Cell 2903 heater or the “Control” cable of the Solid Test Cell 2914 is connected. If these cables are not or wrong connected the software could not detect any test cell and therefore it will not enable the HV ON button because of safety reasons.
Further a cell have to be selected for the 2903:



14.4 Error Assistance

14.4.1 ComError

A “ComError” in the status field of the DC Resistivity measurement, signals no communication with the DC measurement hardware is possible over USB. This error can occur due to several reasons.

1. The USB connection between the 2830 - 2831 is broken. Check the USB cable on the backpanels if it make a prober connection.

2. When a breakdown during the DC resistivity occurs, the communication to the measuring HW can break. Switch off both devices with the power switches and wait 10 seconds, then switch power on again.

3. When the software is started up a self calibration of the DC measurement unit will be done. If the this calibration fail the communication will be stopped. Disconnect all connected cables to the 2831 and switch off both units and switch them on again. If the error will not disappear after 3 times switching off and on again, the please contact the Haefely Support.

15 Conformity

HAEFELY TEST AG

Declaration of Conformity

Haefely Test AG
Birsstrasse 300
4052 Basel
Switzerland

declare, under his own responsibility, that the product here mentioned, complies with the requirements of the listed standards or other normative documents.

So, the product complies with the requirements of the EMC directive 89/336/EEC, 92/31/EEC and 93/68/EEC and the low voltage directive 73/23/EEC and 93/68/EEC.

Product:	**Precision Oil and Solid Dielectric Analyzer 2830/2831**
Description:	The Precision Oil and Solid Dielectric Analyzer 2830/2831 is used to measure and evaluate insulation materials to analyse its losses.
Standards:	EN 61010-1: 2001 EN 61326-1: 2006

R. Mäder
Quality Department Manager
Haefely Test AG
4052 Basel
Switzerland

Basel, February 24, 2012

....
(Signature)

HAEFELY HIGH VOLTAGE TEST — Tettex INSTRUMENTS — HAEFELY TECHNOLOGY
Haefely Test AG, Birsstrasse 300, CH-4052 Basel/Switzerland
www.haefely.com

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