Operating Instructions

HAEFELY TEST AG

MIDAS micro

2883

Mobile Insulation Diagnosis & Analysing System

Version 1.4

4843122

Title	*Operating Instructions MIDAS micro 2883*
Date	*11-2014*
Authors	*TH, DL, LWA*
Layout	*LWA*

Revision History

Version	*Date*	*Author*	*Remarks*
1.0	*06/2014*	*DL TH*	*Initial release of the document*
1.1	*11/2014*	*DG*	*PF formula modified*
1.2	*02/2015*	*TH*	*Changes for firmware V1.1.0 and V1.1.1*
1.4	*03.2018*	*SG*	*FTP Server and Limits added*

WARNING

Before operating the instrument, be sure to read and understand fully the operating instructions. This instrument is connected to hazardous voltages. It is the responsibility of the user to ensure that the system is operated in a safe manner.

This equipment contains exposed terminals carrying hazardous voltages. There are no user serviceable components in the unit. All repairs and upgrades that require the unit to be opened must be referred to HAEFELY TEST AG or one of their nominated agents.

Unauthorized opening of the unit may damage the EMI protection of the system and will reduce its resistance to interference and transients. It may also cause the individual unit to be no longer compliant with the relevant EMC emission and susceptibility requirements. If the unit has been opened, the calibration will be rendered invalid.

In all correspondence, please quote the exact type number and serial number of the instrument and the version of software that is currently installed on it.

Note

HAEFELY TEST AG has a policy of continuing improvement on all their products. The design of this instrument will be subject to review and modification over its life. There may be small discrepancies between the manual and the operation of the instrument, particularly where software has been upgraded in the field. Although all efforts are made to ensure that there are no errors in the manuals, HAEFELY TEST AG accepts no responsibility for the accuracy of this manual.

HAEFELY TEST AG accepts no responsibility for damage or loss that may result from errors within this manual. We retain the right to modify the functionality, specification or operation of the instrument without prior notice.

2014, HAEFELY TEST AG, Switzerland

1.1 Manual Conventions

In the manual, the following conventions are used:

Indicates a matter of note - if it refers to a sequence of operations, failure to follow the instructions may result in measurement errors.

Indicates hazards. There is a risk of equipment damage or personal injury or death. Carefully read and follow the instructions. Be sure to follow any safety instructions given in addition to those for the site at which tests are being performed.

- Text in boldface is used for buttons, device ports and connectors, table headings as well as subtitles in continuous text.
- *Text in italics* is used for menu items, chapter references and notes.
- Underlined text is used for emphasis.

1.2 Abbreviations and Definitions

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

AC	Alternate current
C_X	Test object capacitance
C_N	Standard capacitance
DC	Direct current
DUT	Device under test
HV	High-voltage
LV	Low-voltage
RMS	Root mean square

Contents

2 Introduction

2.1 General

The MIDAS micro 2883 is the smallest, most compact insulation tester on the market. It is designed for power / dissipation factor and capacitance testing in the field and in the factory.

2.2 Scope of Supply

The following items are supplied with a standard single channel system:

Qty	Part No.	Description
1	4842957	Midas micro unit
1	4843122	Manual Midas micro
1	0781811	Memory Stick
1	4843112	Accessories Bag

The accessories consist in the following items:

Qty	Part No.	Description
1	4843309	Bag
2	0781721	Cable Drums for HV and Measuring cables
1	4843042	Cable high voltage 20m
1	4842635	Measuring Cable blue 20m
1	4842636	Measuring Cable white 20m
1	4842637	Measuring Cable yellow 20m
3	4843107	Measuring Cable clamp
2	0781769	Connection wire
2	0780069	Connection clip
1	4843125	Earthing Cable with clamp 20m
1	4843440	High voltage clamp
1	4842106	Extension clamp
2	4843453	Bushing Adapter BNC
1	4843455	Bushing Adapter HV
1	4843115	Handheld with cable 10m
1	0781758	Copper wire 25m / 0.8mm diameter
1	0781631	ODU Connector
1	0780999	Bend protection ODU
2	0781256	Spare Paper Roll for Thermal Printer

Mains cable

A country specific mains cord is also delivered inside the accessories bag.

Part No.	Description
0937401	USA / Japan, 2.0m, 10A
0938201	Switzerland; 2.0m, 10A
0938561	UK, 2.5m, 10A
0194091	China, 2.5m, 10A
0938251	Europe (Schuko), 2.5m, 10A

Optional accessories (not included in standard scope of supply):

Part No.	Description
4843116	Warning Lamp
4843117	Foot Switch
4842187	External Temperature Probe
3490045	Thermohygrometer
4842640	Adapter LEMO to BNC
4840155	Hook for HV Cable
4843459	Hot Collar belt

On receipt of the unit check that all items have been delivered. Also check that the correct power cord for your location has been supplied. In the event of missing or damaged parts please contact your local sales representative stating the serial number, the type of the instrument and the sales order number.

3 Technical Data

Measurement System			
	Range	Resolution	Accuracy
Dissipation Factor (tan δ)	0 .. 100 (0 .. 99'999%)	0.0001 0.01 %	± 0.5 % rdg ±0.0001 @ 50..60 Hz ± 0.5 % rdg ±0.01% @ 50..60 Hz
Power Factor (cos φ)	0 .. 1 (0 .. 100%)	0.0001 0.01 %	± 0.5 % rdg ±0.0001 @ 50..60 Hz ± 0.5 % rdg ±0.01% @ 50..60 Hz
Capacitance	50Hz: 8 pF .. 47 nF @ 12kV 10 pF .. 57 nF @ 10 kV 4 nF .. 22 uF @ 25 V 60Hz: 6.5 pF .. 39 nF @ 12kV 8 pF .. 47 nF @ 10 kV 3 nF .. 19uF @ 25 V	0.01 pF	± 0.3 % rdg ± 0.3 pF
Test Voltage	25 .. 12'000 V_{rms}	1 V	± 0.3 % rdg ± 1V
Test Current	30 µA .. 180 mA_{RMS}	0.1 µA	± 0.3 % rdg ± 1 µA < 0.2A
Watts / Power	0 .. 2.16 kW	0.1 mW, mVA, mVAR	± 0.8 % rdg ± 1 mW, mVA, mVAR
Quality Factor	0.01 .. 10'000	0.0001	± 0.5 % rdg ± 0.0001
Inductance	50Hz: 212 H .. 1.27 MH @ 12kV 177 H .. 1.06 MH @ 10 kV 0.44 H .. 2.65 kH @ 25 V 60Hz: 177 H .. 1.06 MH @ 12kV 147 H .. 884 kH @ 10 kV 0.37 H .. 2.2 kH @ 25 V	0.1 mH	± 0.5 % rdg ± 0.5 mH
Frequency	50 .. 60 Hz @ 12kV 15 .. 400 Hz @ ≤ 5 kV	1 Hz	± 0.1 % rdg ± 0.3 Hz
Output			
Current	≤ 180 mA_{RMS} (20 min ON, 20 min OFF)		
Power	2'160 VA (20 min ON, 20 min OFF)		
Internal Reference			
100 pF Reference Capacitance, tan δ < 0.00001			
Temperature coefficient < 0.01 %			
K Capacitance ageing < 0.01 % / year			

Calibration Interval
2 years recommended

Interfaces	
Display	7” TFT , 800 x 480, Colour Touch Screen
Measurement Inputs	3 x BNC
USB	1 x USB 2.0
Ethernet/LAN	1 x RJ-45

Safety Features
Open Ground Detection
Security Handheld Switch, Foot Switch
Warning Lamp
Audible Warning Signal on High-Voltage ON

Measured Values			
DF (tan δ)	DF (tan δ)$_{@20°C}$	DF%(tan δ)	DF%(tan δ)$_{@20°C}$
PF (cos φ)	PF (cos φ)$_{@20°C}$	PF%(cos φ)	PF%(cos φ)$_{@20°C}$
Capacitance Cx	Resistance Rx	Inductance Lx	Frequency f
Test Current Ix	Mains frequency fm	Noise frequency fn	Apparent Power S
Real Power P	Reactive Power Q	S/N Ratio	Quality Factor QF
Ref Current In	Capacitance Cn	Current Imag (Lp)	Current Ife (Rp)
Phase-angle φ (Zx)	Voltage U_{RMS}	Insulation Temp.	Temp. Corr. Factor K
Conditions	Comments	Connection mode	Time/Date
Settings			

Standards			
Safety	IEC 61010-1 (2010)	EN 61010-1:2001(ZEK 01.4-08)	
EMC	EN 61000-3-2 (2006)	EN 61000-3-3 (2008)	EN 61000-4-2 (2009)
	EN 61000-4-3 (2010)	EN 61000-4-4 (2004)	EN 61000-4-5 (2006)
	EN 61000-4-6 (2007)	EN 61000-4-11(2004)	EN 55011 +A1(2009)
Drop Test	IEC 60068-2-31 Edition 4.0 (face, corner, free fall)		
Shock & Vibration	IEC 60068-2-6	IEC 60068-2-64 Edition 2.0	IEC 60068-2-27
Ageing	MIL-T-28800		

Physical and Environmental Specifications	
Mains Supply	90 .. 264 VAC 50/60 Hz, 800 W, active PFC (acc. IEC61000-3-2)
Protecting Fuse	T 10 A
Connection	Fused IEC-320 connector
Operating Temperature	-10 ... +50°C (14 .. 122 °F)
Storage Temperature	-20 … +70°C (-4 .. 158 °F)
Relative Humidity	5 ... 95 %, non-condensing
Dimensions (W x D x H)	54.6 x 34.7 x 24.7 cm (21.5” x 13.66” x 9.72”)
Weight Unit	24.9 kg (55 lb)
Weight Accessories Bag	16 kg (35.7 lb)

4 Safety

Safety is the responsibility of the user. Always operate the equipment in accordance with the instructions, always paying full attention to local safety practices and procedures.

This warning sign is visible on the MIDAS micro 2883 unit. Meaning: This equipment 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 due to none observance of instructions contained herein or due to incorrect use of the MIDAS micro 2883.

☠	**Remember:**	**Hazardous voltage can shock, burn or cause death!**

4.1 General

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

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 Haefely Test AG recommendations.

The MIDAS micro 2883 generates high voltage and is capable of causing serious or even lethal electrical shock. If the instrument is damaged or it is possible that damage has occurred, for example during transportation, do not apply any voltage.

The instrument may only be used under dry operating conditions. The use of MIDAS is prohibited in rain or snow.

Do not open the MIDAS micro 2883, it contains no user replaceable parts.

Do not switch on or operate a MIDAS micro 2883 instrument if an explosion hazard exists.

4.2 Personnel Safety

The MIDAS micro 2883 should not be operated by a crew smaller than two people. Their function can be described as follow:

Test Operator: The person who is making the test connections and operates the MIDAS micro 2883. He must be able to have a clear view of the device under test and the area where the test is performed.

Safety Observer: The person who is responsible for observing the performance of the test, seeing any safety hazard, and giving warning to crew members.

Both persons should perform no other work while the MIDAS micro 2883 is energized.

While making the various types of connections involved in the different tests, it may be necessary for personnel to climb up on the equipment, but no one should remain on the equipment during the test itself.

Non-test related persons who are working in proximity to the area where testing is performed must be informed. Consistent visual and verbal signals should be agreed and followed.

Perform only one job at a time on any equipment. The situation in which two crews are doing different tasks with the same equipment at the same time is an open invitation for confusion, trouble, and danger to the personnel.

People with heart pacemakers should not be in the vicinity of this system during operation.

4.3 Safety Features

Beside an *Emergency Stop* switch the MIDAS micro 2883 is equipped with an external *Safety Switch* (spring-release type or a 'dead man' type). The Safety Switch should be controlled by the second test crew member (safety observer). Without the Safety Switch the instrument cannot be activated.

Prior to making the first measurements, the Safety Switch operator should verify the correct operations of the switch.

It is recommended that the Safety Switch be the last switch closed. It must remain open until all personnel are safely in the clear. If unauthorized personnel should enter the area, or if some other undesirable situation should develop, the Safety Switch operator should release the switch immediately, and then notify the MIDAS micro 2883 operator.

The Safety Switch should be used at all times. Never short circuit it and do not use fixed mechanical locking devices for depressing the switch button. The switch button must be manually operated at all times.

For visual warning of high voltage presence a warning bar is located in the screen of the instrument. Optional a strobe light is delivered which can be mounted on the device under test.

The MIDAS micro 2883 is equipped with a HV GND connection surveillance. The high voltage can only be switched on when the earth circuit is properly connected. The instrument indicates the status by software.

A separate green/yellow earth cable is provided for the purpose of safety grounding the instrument. The earth cable should be connected to the Earthing Screw on the front panel of the MIDAS micro 2883 at one end and to the station grounding system at the other end.

The green - yellow safety ground cable should be the FIRST lead to be connected to the set.

4.4 Safety Precautions

All tests must be performed with the device under test completely de-energized and isolated from its power systems. The equipment, its tank or housing must be disconnected from all buses and properly earthed, so that all induced voltages or trapped charges are neutralized. Only when the measurement procedure is actually being performed the grounds should be temporarily removed if necessary.

The MIDAS micro 2883 must be solidly earthed with the same ground as the device under test. When the instrument is permanently housed in a vehicle, the MIDAS micro 2883 ground should be bounded to the vehicle chassis, which in turn is grounded.

Exposed terminals of equipment should not normally be allowed to 'float'. They should be grounded directly or through the low voltage leads “Input V (Guard)” of the MIDAS micro 2883, unless otherwise specified.

Testing of high voltage equipment involves energizing the equipment through the MIDAS micro 2883. This can produce dangerous levels of voltage and current. Care must be taken to avoid contact with the equipment being tested, its associated bushings and conductors, and with the MIDAS micro 2883 cables. Especially the high voltage test cable should not be held during energization of the instrument. Flashover of the test specimen or the MIDAS micro 2883 can generate transient voltages of sufficient magnitude to puncture the insulating jacket of the high voltage test cable.

It is strongly recommended that the test crew make a visual check to ensure that the equipment terminals are isolated from the power system. If there is real possibility that the device under test fails precautions such as barriers or entrance restrictions must be taken against harm in the event of violent failure.

Proper clearance between the test equipment and the device under test must be ensured during the presence of high voltage. Barriers and safety tapes can be established around the test area to prevent unintentional entry into the live area. It must also be guaranteed that extraneous objects like ladders, buckets, etc. cannot enter the test area.

After the MIDAS micro 2883 is properly grounded, the remaining test leads and the High Voltage Test Cable are plugged into their receptacles. Do not connect test leads to the equipment terminals until after the leads are connected to the MIDAS micro 2883.

The safety observer should supervise the proper procedures for connecting the MIDAS micro 2883 leads to the device under test at all times.

The MIDAS operates from a single-phase power source. It has a three wire power cord and requires a two-pole, three terminal, live, neutral and ground type connector. Do not bypass the grounding connection. Any interruption of the grounding connection can create electric shock hazard. The power input connection should be the last step in setting up the instrument.

After the tests are completed, all test leads should be disconnected first from the device under test and earthed before they are disconnected from the instrument.

The green / yellow safety ground cable should be the LAST lead to be disconnected from the set.

Do not disconnect the voltage cables from the front panel of the Midas micro unless the MIDAS micro 2883 Voltage is set to HV OFF, and the Safety Switch is released. Attempts to disconnect leads while the MIDAS micro 2883 is energized may result in a serious and possibly lethal electrical shock.

4.5 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.

In addition to the obvious dangers, personnel should be alert to recognize subtle dangers as well. For example, during transformer excitation-current tests, the floating terminals may have significant voltages induced in them by simple transformer action. Therefore, all terminals of a device under test, unless grounded, should be considered to be live while the test is in progress.

When potential transformers or any transformers are interconnected, voltage can be back-fed through the secondary windings to produce high voltage on the primary although the primary is seemingly isolated from the power system. This entail a second important rule - all terminals of a device under test should be completely isolated.

Finally it should be noted that the MIDAS micro 2883 is relatively lightweight. It can be lifted by a single person. We recommend however that you lift it carefully and ergonomically in order to prevent injuries.

Make sure not to trap any fingers or cables when closing the Midas micro lid. The sharp edges might injure you or damage the insulation.

Remember: Safety, FIRST, LAST, ALWAYS!

5 Theory

5.1 Why is Insulation Tested?

All transformers, high voltage switchgear, motors and electrical equipment accessories have a high voltage lifespan. From the first day of use the equipment is subject to thermal and mechanical stresses, foreign particle ingress and variations in temperature and humidity. All of these influences raise the working temperature of the equipment when switched on. This heating accelerates chemical reactions in the electrical insulation, which result in a degradation of the dielectric characteristics. This process has an avalanche character i.e. the changing electrical characteristics of the insulation increase the loss factor and produce heating which further degrades the insulation. If the loss factor of the insulation is periodically monitored and recorded, it is possible to predict and / or avoid catastrophic failure of the electrical equipment.

At the beginning of the public electricity supply industry, methods and processes were sought to avoid unexpected losses caused by equipment defects. One method that provided repeatable data and offered simple on-site measurement was the measurement of capacitance and loss factor (power factor) of the equipment insulation.

In cases where loss factor tests were regularly carried out, and the relevant test results compared with earlier results, the deterioration of the insulation was noted and necessary preventative measures were carried out. Based on this groundwork, a series of test procedures were developed and described in various IEEE, ANSI and IEC documents and standards to specify the insulation quality for various types of electrical equipment.

In this way the degradation of the insulation characteristics over a specified period of time can be determined. With the test result history an experienced engineer is able to take the necessary maintenance actions based upon changes in the value of loss factor.

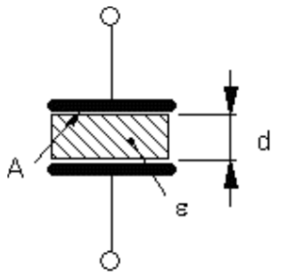
5.2 What is Loss Factor?

Loss factor is the total energy that will be used by the equipment during normal service. In particular, the insulation loss factor is any energy that is taken by the flow of current through the resistive component of the insulation. The earth path varies according to the type of electrical equipment. For example, switchgear will probably develop tracking to earth at right angles to the floor connections. In transformers paths can develop in the insulation resistance between the windings or between the windings and housing (tank). In all cases the result is a loss factor in the form of heating.

Note: In this text loss factor (losses, watts) is referred to, in contrast with total loss factor. Total loss factor is normally used to describe the total losses of the transformer under load and should not be confused with the energy that is lost due to degradation of the insulation.

5.3 What is Dissipation Factor tan δ?

To specify the insulation loss factor, the test object must be considered in the test arrangement as a capacitor. Consider all test objects e.g. transformers, bushings, bus bars, generators, motors, high voltage switchgear etc. are constructed from metal and insulation, and therefore possess associated capacitive properties. Every test object consists of various capacitances together with the insulation and the internal capacitance to earth. The figure shows the components that comprise a capacitance and the diagram for a simple disc capacitor.



Disc Capacitor

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

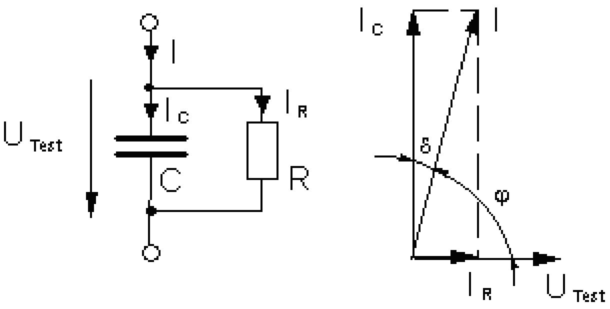
where:

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	$\varepsilon = \varepsilon_0 \bullet \varepsilon_r$, 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°.

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 lossy capacitance with vector diagram

Loss factor (Dissipation Factor)

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

Power Factor

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

U_{Test}	applied test voltage
I_C	current through capacitance
I_R	current through resistance (insulating material)
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.

5.4 The Difference between Power Factor and Dissipation Factor

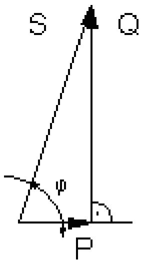
While “Dissipation Factor” tan δ is used in Europe to describe dielectric losses, the calculation used in the United States is „Power Factor“ cos φ.

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 the difference is negligible. However the conversion formulas are:

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

5.5 Apparent Power, Real Power, Reactive Power

The relationship between the various types of power is clarified in the following equations.



Apparent Power	S = U·I	[VA]
Real Power	P = U·I cos φ	[W]
Reactive Power	Q = U·I sin φ	[var]

Vector Diagram of Apparent Power, Real power and Reactive Power

Because most test objects are not a pure resistance and therefore have a phase angle φ between the test voltage and current, this phase shift must also be taken into consideration in the power calculation.

5.6 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. 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. The MIDAS micro 2883 incorporates the double vector-meter 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.

5.7 Evaluation of Test Results

5.7.1 Significance of Capacitance and Dissipation Factor

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 knowledge of the apparatus construction and the characteristics of the types of insulation 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 equipment being tested, and by observing these differences:
- Between measurements on the same unit after successive intervals of time.
- Between measurements on duplicate units or a similar part of one unit, tested under the same conditions around the same time, e.g., several identical transformers or one winding of a three phase transformer tested separately.
- Between measurements made at different test levels on one part of a unit; an increase in slop (tip-up) of a dissipation factor versus voltage curve at a given voltage is an indication of ionization commencing at that voltage.

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 may 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.

Unless bushing and pothead surfaces, terminal boards, etc., are clean and dry, measured values not necessarily apply to the insulation under test. Any leakage over terminal surfaces may add to the losses of the insulation itself and may give a false indication of its condition.

5.7.2 Dissipation Factor of Typical Apparatus Insulation

Values of insulation dissipation factor for various apparatus are shown in this table. These values are useful in roughly indicating the range to be found in practice; however, the upper limits are not reliable service values.

Equipment	Dissipation factor @ 20°C
Oil-filled transformer, new, HV (> 115kV)	0.25% .. 1.0%
Oil-filled transformer, age 15 years, HV (> 115kV)	0.75% .. 1.5%
Oil-filled transformer, age 15 years, LV, distribution	1.5% .. 5%
Circuit breakers, oil-filled	0.5% .. 2.0%
Oil-paper cables, "solid" (up to 27.6 kV) new	0.5% .. 1.5%
Oil-paper cables, HV, oil-filled or pressurized	0.2% .. 0.5%
Stator windings, 2.3 .. 13.8kV	2.0% .. 8.0%
Capacitors	0.2% .. 0.5%
Bushings, (solid or dry)	3.0% .. 10.0%
Bushings, compound-filled, up to 15kV	5.0% .. 10.0%
Bushings, compound-filled, 15 .. 46kV	2.0% .. 5.0%
Bushings, oil-filled, below 110 kV	1.5% .. 4.0%
Bushings, oil-filled, above 110 kV	0.3% .. 3.0%

5.7.3 Dissipation Factor and Dielectric Constant of Typical Insulation Materials

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

Material	Dissipation factor @ 20°C	ε
Acetal resin (Delrin™)	0.5%	3.7
Air	0.0%	1.0
Askarels	0.4%	4.2
Kraft paper, dry	0.6%	2.2
Transformer oil	0.02%	2.2
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%	7.0
Material	**Dissipation factor @ 20°C**	**ε**
Rubber	4.0%	3.6

Silicone liquid	0.001%	2.7
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.

5.7.4 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. On transformers and similar apparatus, measurements during cooling (after factory heat-run or after service load) can provide required temperature correction factors.

To compare the dissipation factor value of tests made on the same or similar type of equipment at different temperatures, it is necessary to correct the value to reference temperature base, 20°C (68°F). The MIDAS micro does that automatically, when the DUT is correctly defined. See also chapter 12.1 DUT tab in the description of software setup.

The insulation material temperature for apparatus such as spare bushings, insulators, air or gas filled circuit breaker and lightning arresters is normally assumed to be the same as the ambient temperature. For oil-filled circuit breakers and transformers the insulation temperature is assumed to be the same as the oil temperature. The (transformer mounted) bushing insulation temperature can be assumed to be the midpoint between the oil and ambient temperatures.

The capacitance of dry insulation is not affected by temperature; however, in the case of wet insulation, there is a tendency for the capacitance to increase with temperature.

Dissipation factor-temperature characteristics, as well as dissipation factor measurements at a given temperature, may change with deterioration or damage of insulation. This suggests that any such change in temperature characteristics may be helpful in assessing deteriorated conditions.

Be careful making measurements below the freezing point of water. A crack in an insulator, for example, is easily detected if it contains a conducting film of water. When the water freezes, it becomes non-conducting, and the defect may not be revealed by the measurement, because ice has a volumetric resistivity approximately 100 times higher than that of water. Tests for the presence of moisture in solids intended to be dry should not be made at freezing temperatures. Moisture in oil, or in oil-impregnated solids, has been found to be detectable in dissipation factor measurements at temperatures far below freezing, with no discontinuity in the measurements at the freezing point.

Insulating surfaces exposed to ambient weather conditions may also be affected by temperature. The surface temperature of the insulation specimen should be above (never below) the ambient temperature to avoid the effects of condensation on the exposed insulating surfaces.

5.7.5 Influence of Humidity

The exposed surface of bushings may, under adverse relative humidity conditions, acquire a deposit surface moisture which can have a significant effect on surface losses and consequently on the results of a dissipation factor test. This is particularly true if the porcelain surface of a bushing is at temperature below ambient temperature (below dew point), because moisture will probably condense on the porcelain surface. Serious measurement errors may result even at a relative humidity below 50% when moisture condenses on a porcelain surface already contaminated with industrial chemical deposits.

It is important to note that an invisible thin surface film of moisture forms and dissipates rapidly on materials such as glazed porcelain, which have negligible volume absorption. Equilibrium after a sudden wide change in relative humidity is usually attained within a matter of minutes. This excludes thicker films which result from rain, fog, or dew point condensation.

Surface leakage errors can be minimized if dissipation factor measurements are made under condition where the weather is clear and sunny and where the relative humidity does not exceed 80%. In general, best results are obtained if measurements are made during late morning through mid-afternoon. Consideration should be given to the probability of moisture being deposited by rain or fog on equipment just prior to making any measurements.

5.7.6 Influence of Surface Leakage

Any leakage over the insulation surfaces of the specimen will be added to the losses in the volume insulation and may give a false impression as to the condition of the specimen. Even a bushing with voltage rating much greater than the test voltage may be contaminated enough to cause a significant error. Surfaces of potheads, bushings, and insulators should be clean and dry when making measurement.

It should be noted that a straight line plot of surface resistivity against relative humidity for an uncontaminated porcelain bushing surface results in a decrease of one decade in resistivity for a nominal 15% increase in relative humidity.

5.7.7 Electrostatic Interference

When tests are conducted in energized sub stations, the readings may be influenced by electrostatic interference currents resulting from the capacitance coupling between energized lines and bus work to the test specimen.

The measurement difficulty, which is encountered when testing in the presence of interference, depends not only upon the severity of the interference field but also on the capacitance and dissipation factor of the specimen. Unfavourable weather conditions such as high relative humidity, fog, overcast sky, and high wind velocity will increase the severity and variability of the interference field. The lower the specimen capacitance (and its dissipation factor), the bigger the difficulty to make an accurate measurement. It is also possible that a negative dissipation factor reading may be obtained so it is necessary to observe the polarity sign for each reading.
The MIDAS micro 2883 interference suppression feature minimizes the influences but however, the influences may be minimized considerably by:

- Using the maximum voltage of the test set if possible.
- Disconnecting and grounding as much bus work as possible from the specimen terminals.
- Making measurements on a day when the weather is sunny and clear, the relative humidity is less than 80%, the wind velocity is low, and the surface temperature of exposed insulation is above the ambient temperature.

5.7.8 Negative Dissipation Factor

It is believed that a complex tree network of capacitances and resistances, which exist within a piece of equipment, cause the negative dissipation factor phenomenon. Error currents may flow into the measuring circuit in instances where phantom multiple terminals or a guard terminal appear in the measurement system. It is also believed that a negative dissipation factor may be produced by currents flowing into a tee network as a result of space coupling from electrostatic interference field.

If the dissipation factor of the measured capacitance would be lower than the one of the built-in standard capacitor the displayed factor would be negative. But that’s only a theoretical case. If negative dissipation factors are seen in daily work one should carefully recheck the test setup and all connections.

5.8 Standard Capacitor, Measuring Current & Limits

To evaluate the expected values of test current, standard capacitor current, the corresponding limiting parameters and the resulting load range use these basic conditions and rules:

(1) Maximum test voltage shall be less than the nominal voltage of the standard capacitor.	$U_{Testmax} \leq U_{CN}$
ⓘ Current through standard capacitor CN	$I_{CN} = U_{Test} \cdot 2 \cdot \pi \cdot f \cdot C_N$
ⓘ Current through capacitor Cx	$I_{Cx} = U_{Test} \cdot 2 \cdot \pi \cdot f \cdot C_x$
(2) Minimum current through standard capacitor CN or test Object Cx Note: Minimal current through CN (internal) to ensure accuracy	$I_{C\ min} \geq 30$ µA
(3) Maximum current through capacitor Cx Note: Maximum current provided by the built in high voltage source	$I_{Cxmax} \leq 180$ mA
(4) Maximum test voltage **	$U_{Test\max} = \frac{I_{Cx\max}}{2 \cdot \pi \cdot f \cdot C_x}$
(5) Minimum test voltage ***	$U_{Test\min} = \frac{I_{C\min}}{2 \cdot \pi \cdot f \cdot C_N}$
ⓘ Test current I_X through test object C_X	$I_x = U_{Test} \cdot 2\pi \cdot f \cdot C_x$
(6) Maximum Test current through test object C_X Note: Maximum input current of the “INPUT A, B, HVGND” to avoid overload	$I_{X\ max} \leq 180$ mA
(7) Minimum Test current through test object C_X Note: Minimal input current of the “INPUT A, B, HVGND” to ensure accuracy	$I_{X\ min} \geq 30$ µA
(8) Limitations based on “Technical Data” (e.g. max supply power, current etc.)	

Note: These calculations are valid for capacitive test objects (tan δ = 0). They can also be as a close approximation for test objects with a tan δ value < 0.01.

* Maximum current trough “$C_{N\ INTERNAL}$” is limited by 12kV / 100pF ⇒ 470µA @ 50Hz

** The max. output voltage is limited to 12kV. The max. output power can also limit the maximum test voltage

*** if Cx<CN, use Cx in this formula instead

Examples:

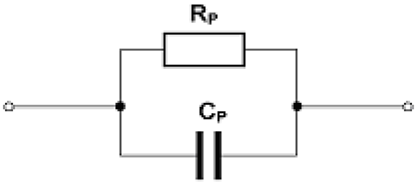
C_X=50nF (tan δ < 0.01), f=50Hz

$$\rightarrow U_{Test\max} = \frac{180mA}{2 \cdot \pi \cdot 50 \cdot 50 \cdot 10^{-9} F} = 11.46kV$$

C_X=50pF (tan δ < 0.01), f=50Hz $\rightarrow U_{Test\,min} = \dfrac{30uA}{2 \cdot \pi \cdot 50 \cdot 50 \cdot 10^{-12} F} = 1.91kV$

5.9 Parallel & Series Equivalent Circuits

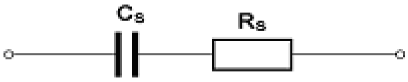
The MIDAS micro 2883 measures the parallel equivalent circuit values.
The following formulas describe the calculation of the value conversion parallel – series :



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

* measured values

Parallel equivalent circuit C_p-R_p



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

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

* measured values

Series equivalent circuit C_s-R_s

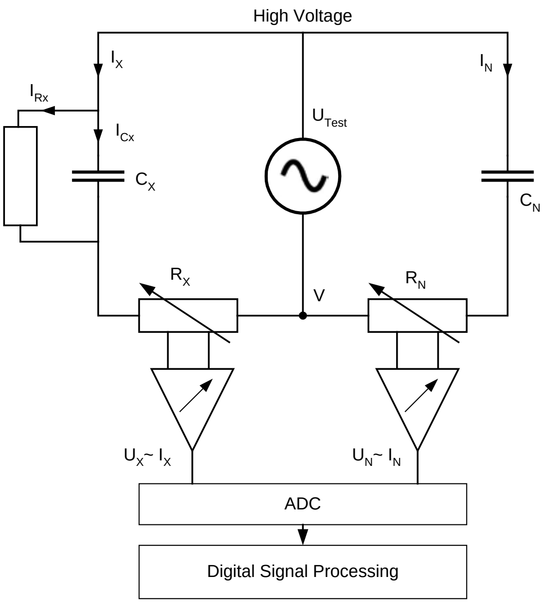
6 Functional Description

6.1 System Overview

To be able to execute correct and reproducible measurements it is essential to understand how the MIDAS micro 2883 measuring system works.

The MIDAS 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 built-in HV AC power source (U_{Test}) and both currents are measured by the adjustable high accurate shunts R_X and R_N and then digitised. The digitised data streams are fed into a CPU and by comparison of the two measured currents and knowing the exact values of the standard capacitor all other desired measuring values can now be determined.



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
	Differential Amplifiers
ADC	Analogue to Digital Converter

Functional Schematics

6.2 V-potential 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 with the DUT - are influencing the measuring values significantly. So these unwanted stray capacitance effects have to be eliminated.

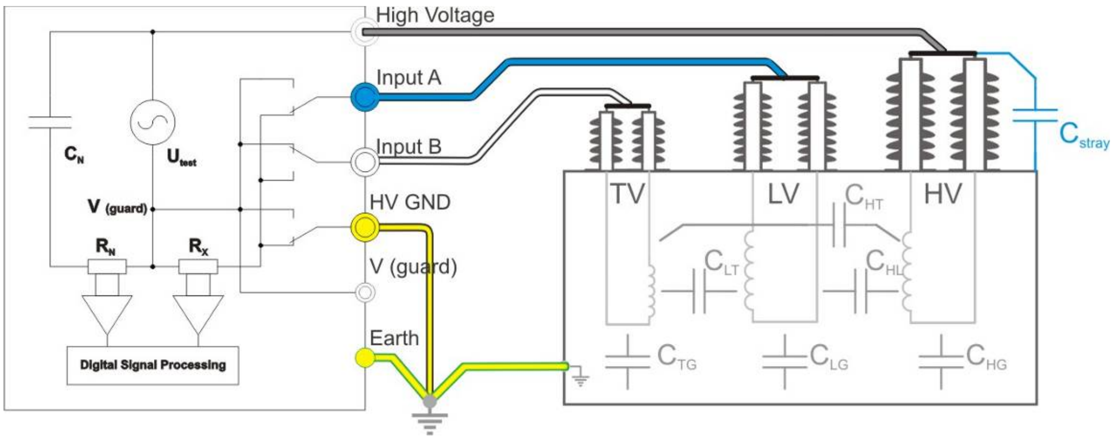
This is realized by the so called “guarding” of the relevant elements. That means that the complete high voltage source, the supply and measuring cables have to be shielded with the so called “V-potential” which is the low voltage point (reference) of the high voltage supply. All capacitances connected to this reference point are bypassed and are therefore not influencing the measuring value. Due to this guarding concept the supplied shielded coax measuring cables (for High Voltage Supply, Input A and Input B) 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-point are bypassed. Make sure that all unwanted capacitances are related to the V-potential point and their current is flowing directly into the V-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. Most cases can be solved by setting the internal Test Mode Switch matrix correctly which sets unused measuring cables and connected parts to the V-potential automatically.

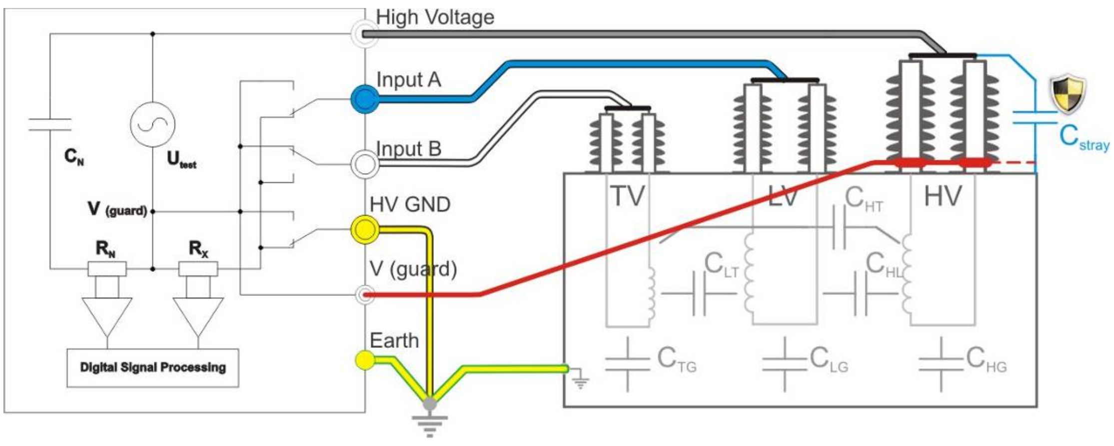
The V-potential point is accessible over a 4mm plug on the instruments front panel where the user can connect external parts of a test setup.

Example: Bypass the leakage current on bushing surface with guarding.



Measurement without guard (V-Potential)

Above figure shows the normal connection in GST gA+B mode to measure the high voltage winding to tank C_{HG}. But with this connection the stray capacitance C_{stray} (surface leakage current on bushing surface) is measured in parallel and therefore causes a minor error on the measurement. The measured value is C_{HG}. + C_{stray}



Measurement with connected V-potential point to the powered bushings (guarding)

With guard collars mounted on the bushings surface close to the tank (not touching). These electrodes, connected to the V-potential point bypass now the leakage current and therefore also the stray capacitance C_{stray} The measured value is now only C_{HG}. and the best accuracy is reached.

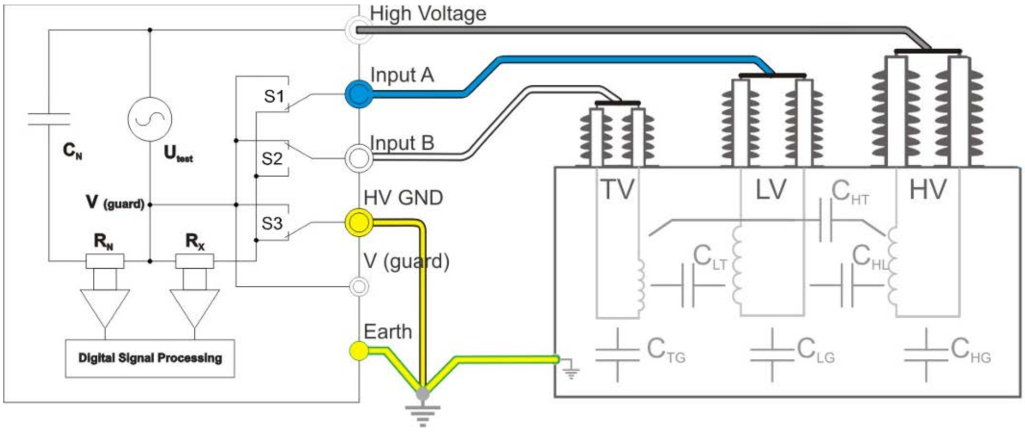
Note: As guard collar you can use any conducting material as aluminium foil, copper band, etc.

6.3 Test Modes

When measuring transformers and other test objects the problem often arises that, in addition to the „normal“ ungrounded capacitances, capacitances with one side grounded must also be measured (e.g. capacitance between a winding and an earthed housing).
Conventional measurement systems require the external test setup (cable connections) to be changed for such

measurements. This involves a lot of work and time, especially when on-site measurements are being performed on large power transformers.

Using the different Test Modes, the test object only has to be connected once for measurement and all relevant capacitances can be measured by switching the connections as required. The selected Test Mode connects the DUT current path(s) to the internal current measuring shunt R_X and the other (not measured) connected leads to the V-potential (reference point) of the system. All capacitances connected to this reference point are bypassed and are not influencing the selected measurement.



Measuring setup on a single phase transformer with two low voltage windings.

Note: The connection between HV GND on the measuring instrument and the earth point of the test object is a normal measuring channel as well. A good clean contact is essential.

The table below gives an overview which test mode measures which capacitances.

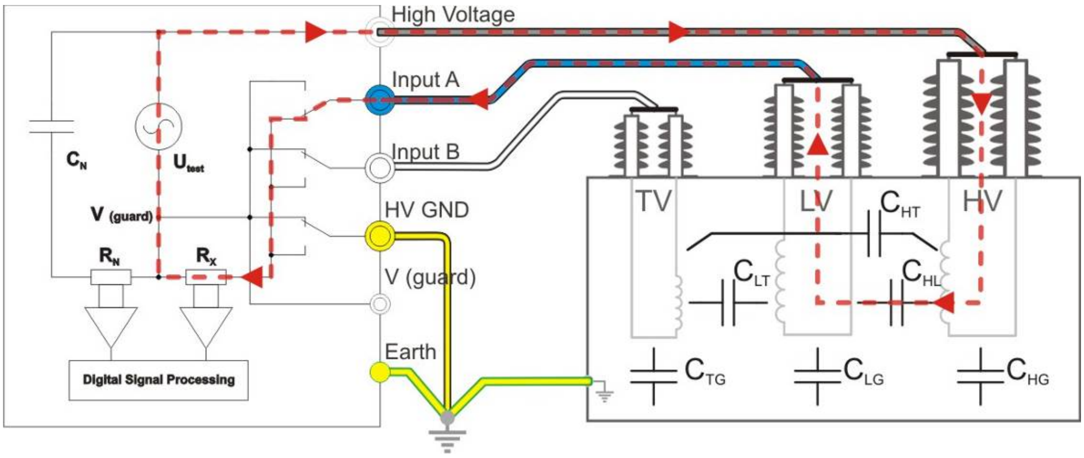
Test Mode	Explanation	INPUT A connected to (S1)	INPUT B connected to (S2)	HV GND connected to (S3)	Actual measured C_X
UST A	Ungrounded Specimen Test, A used as measuring channel, B and HV GND connected to V- potential point (bypassed)	R_X	V	V	C_{HL}
UST B	Ungrounded Specimen Test, B used as measuring channel, A and HV GND connected to V- potential point (bypassed)	V	R_X	V	C_{HT}
UST A+B	Ungrounded Specimen Test, A and B used as measuring channels, HV GND connected to V-potential point (bypassed)	R_X	R_X	V	C_{HL} + C_{LT}
GST A+B	Grounded Specimen Test, A and B and HV GND used as measuring channels.	R_X	R_X	R_X	C_{HL} + C_{HT} + C_{HG}
GSTgA	Grounded Specimen Test with guarding (V-potential) connected to A (bypassed). HV GND and B are used as measuring channels.	V	R_X	R_X	C_{HT} + C_{HG}
GSTgB	Grounded Specimen Test with guarding (V-potential) connected to B (bypassed). HV GND and A are used as measuring channels.	R_X	V	R_X	C_{HL} + C_{HG}
GST gA+B	Grounded Specimen Test with guarding (V-potential) connected to A and B (bypassed). Only HV GND is used as measuring channel.	V	V	R_X	C_{HG}

Note: For testing the insulation secondary winding – tank, the HV cable and measuring cables shall be exchanged. The HV shall be connected to the secondary winding(s) and the measuring cable to the primary winding. The measured capacitances in the table will change accordingly.

6.3.1 Test Mode „UST" for ungrounded test objects

This test mode is the most common situation when measuring capacitance and dissipation factor. Various ungrounded capacitances can be measured using this mode, providing that the maximum test current of the measuring instrument is not exceeded.
When measuring power transformers and HV current transformers, this configuration determines the capacitance and dissipation factor between the various winding groups.

In this mode the highest measurement accuracy is reached.

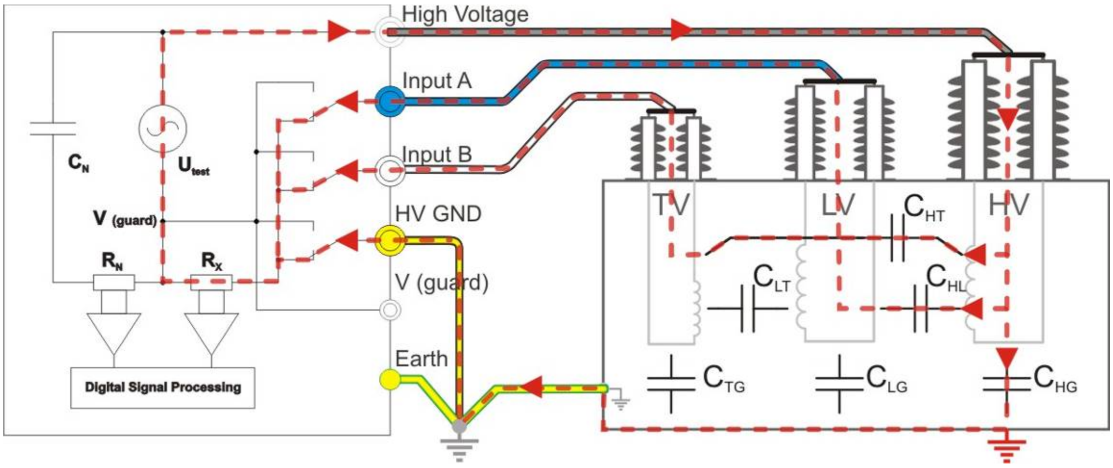


UST A Measurement

The above figure shows a three winding transformer as a typical example (note: for simplicity only one phase per winding is shown). There exist various capacitances, in between the windings and between the windings and tank/ground (C_{HT}, C_{HG}, etc.). Shown is the UST A configuration, where the measuring input A is switched by the internal relay to the measuring shunt (precision resistor). The inputs B and HV GND are connected to the V (guard) potential. The current circulates from the High Voltage output through the capacitance C_{HL} and the resistor R_x. All other capacitances (i.e. C_{HT}, C_{HG}) are connected to the V-potential. The current flowing through these capacitances is therefore not taken into the measurement.

6.3.2 Test Mode „GST" for grounded test objects

This test mode enables the measurement of capacitances that are normally earthed on one side when in operation. When measuring transformers, this configuration measures the capacitance and dissipation factor between the HV winding and all other windings and the transformer housing.

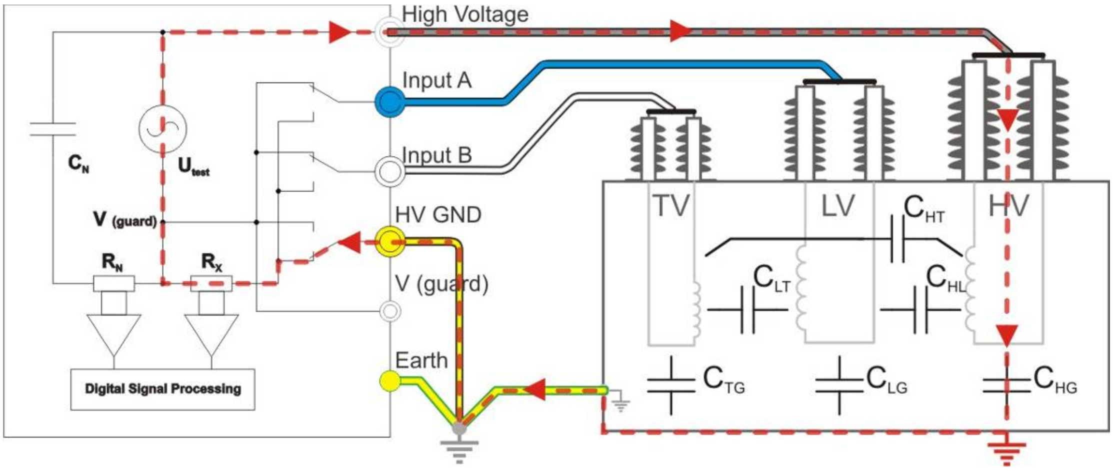


GST A+B measurement

Above figure shows the same three winding transformer in a GST A+B test mode configuration. The current circulates from the High Voltage output through the capacitances C_{HL}, C_{HT} and C_{HG} and through R_x. The total measured capacitance represents the sum of the three capacitances.

6.3.3 Test Mode „GST g“ for grounded test objects with guarding (V-potential)

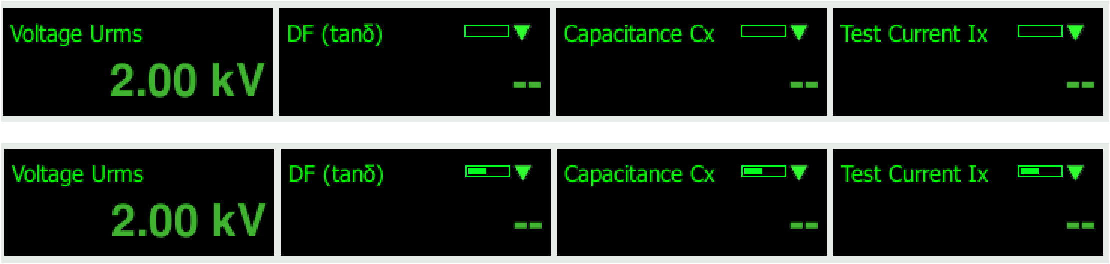
This test mode directly measures the capacitance between the HV terminal and the housing (which is grounded). The partial capacitances that are undesirable for the measurement are connected to the V-potential point and thereby rendered ineffective.
When measuring transformers, this configuration measures the capacitance and dissipation factor between the various winding groups and the transformer housing. The windings which are not used for measurement are connected to the v-potential of the measuring system via the A (or B) measuring cable and the internal Test Mode Switch.



GST g(A+B) measurement

6.4 Interference Suppression

The presence of power line frequency fields induce spurious voltages and currents (interference inductions) onto the test object and therefore cause an error on the measuring signal. These interferences make accurate measurement more difficult. The Midas micro uses therefore special filter algorithms to reduce the noise and extract the measuring signal. These algorithms are started automatically whenever a low signal to noise ratio is detected. The user is informed about the progress of the measurement by small progress bars in the actual measurement area. When the progress bar is full a new accurate measurement value has been determined and will be displayed. The measurement will take a little bit longer when these algorithms are applied, please be patient and do not release the handheld before the measurement is complete.

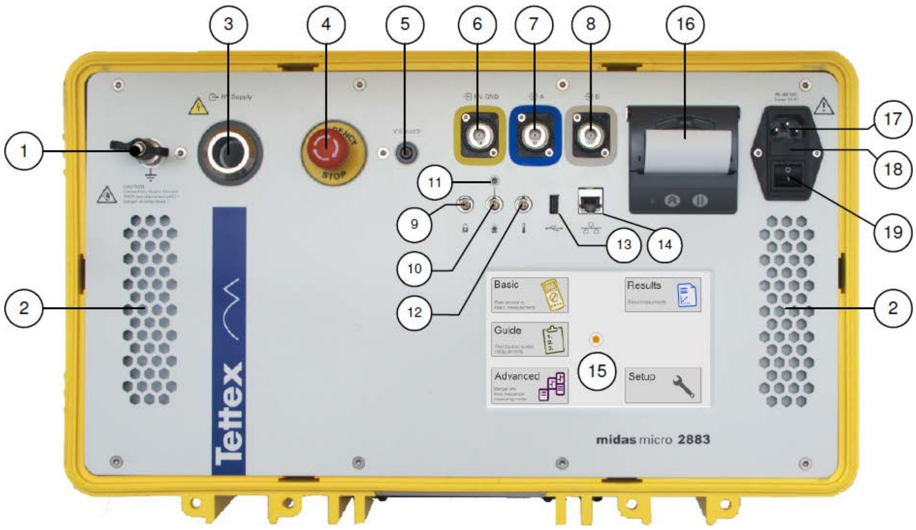


The progress bar during interference suppression measurement

The Midas micro 2883 interference suppression makes accurate measurements possible even in adverse interfering environment.

7 Operation Elements

7.1 Front-Panel Features



1	Ground Terminal / Earthing
2	Ventilation Slots
3	High Voltage Output
4	Emergency Stop Button
5	Low Voltage Point V
6	Measuring Input HV GND
7	Measuring Input A
8	Measuring Input B
9	Safety Switch Input
10	External Warning Lamp Output
11	Warning Lamp
12	Temperature Sensor Input
13	USB Port
14	Ethernet Port
15	Display with Touch panel
16	Printer
17	Socket for mains cable
18	Box for mains fuses
19	Power Switch

7.1.1 Ground Terminal

Wing nut ground terminal for connecting the safety ground lead to earth ground (connected to the instruments housing and the ground pin from the mains connector, there is no measuring or AC supply functionality)

A separate green/yellow earthing cable is provided for the purpose of safety grounding the instrument. The Safety Ground cable should be connected to the Earthing Screw on the left side of the front panel of the Midas micro at one end and to the station grounding system at the other end.

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

7.1.2 Ventilation Slots

The ventilation slots allow air cooling with the integrated fans.

Do not block any of the ventilation slots. Keep clean for proper cooling.

7.1.3 High Voltage Output

Plug receptacle for connecting the high voltage output cable (grey) respectively the test object

7.1.4 Emergency Stop Button

When the Emergency Stop Button is pressed the test is automatically terminated (high voltage is switched off and it is not possible to switch the high voltage on until the button is released)

The emergency stop switch is directly integrated in the safety interlock circuit (hardwired) without any interaction of the built-in CPU or software.

7.1.5 Low Voltage Point V

4 mm plug for connecting all parts which capacitance shall not be measured (with this reference "v" potential the HV transformer and the entire HV circuit is enclosed → Guard. It is also the low voltage point of the HV supply, NOT the system earth)

7.1.6 Measuring Input HV GND

Plug receptacle for connecting the low voltage test lead HV GND. This input is used for measuring grounded specimens. The maximum input current is limited to 200mA.

7.1.7 Measuring Input A

Plug receptacle for connecting the low voltage test lead A. The maximum input current is limited to 200mA.

7.1.8 Measuring Input B

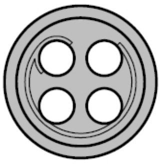
Plug receptacle for connecting the low voltage test lead A. The maximum input current is limited to 200mA.

7.1.9 Safety Switch Input

Plug receptacle for connecting the handheld Safety Switch.

The Safety Switch should be used at all times. Never short circuit it and do not use fixed mechanical locking devices for depressing the switch button. The switch button must be manually operated at all times.

The safety switch input can also be used as an interlock in an automated system. In this case the responsibility for the safety lies entirely with the provider of the automated system. Connecting anything different than the equipment provided by Tettex may result in damaging the device.



1 4

2 3

(front view)

Pinout

Pin	Signal
1	Output +12V protected 45mA
2	Input. Do only connect to Pin 1!
3	+12V Output protected 2.5A max → +12 V when status is “ready” → Intermittent 12 V / 0V when status is “HV on” → 0V when not ready (i.e. warning or error present)
4	GND

7.1.10 External Warning Lamp Output

Plug receptacle for connecting the optional external warning lamp (optional, see chapter 15 Accessories and Options)

Pinout

Pin	Signal
1	+12V Output protected 2.5A max: → +12 V when status is “ready” → Intermittent 12 V / 0V when status is “HV on” → 0V when not ready (i.e. warning or error present)
2	GND

7.1.11 Warning Lamp

The LED on the front panel indicates the actual high voltage state of the Midas micro 2883 (see chapter 4 Safety).

Off	High voltage output is short circuited → no danger from the device.
On	The system is ready to start HV. Selecting HVon on the touchscreen will power up the HV source.
blinking	HV is on → Danger!

7.1.12 External Temperature Sensor

Plug receptacle for connecting an external temperature probe (optional, see chapter 15 Accessories and Options). The sensor can be attached to the DUT magnetically.

The temperature is measured in a 4-wire configuration.

Pinout

Pin	Signal
1	Supply +
2	Sense Wire +
3	Sense Wire -
4	Supply -

7.1.13 USB Port

Plug external memory storage here in order to export measurement data (see subchapter USB Transfer in chapter File Menu) or to perform a Software Update (see chapter 12.7).

7.1.14 Ethernet Port

The Ethernet port is used for manufacturer's service purposes.

Further the Midas micro can also be remote controlled with a VNC Client over the Ethernet Port.
To use this functionality go to setup in order to lookup the IP Address of the Midas micro.
Enter this IP Address into the VNC Client and make sure the two devices are in the same network.
Start the VNC software tools and remote control the Midas micro over LAN.

The manufacturer takes no responsibility for a failure-free functionality of the Midas micro connection and operation via third party software (VNC tools) to an external PC or laptop.

7.1.15 Touchscreen

Display with resistive touch panel. Touchscreen reacts to physical pressure. Only one pressure point can be detected at once (no multitouch). Use of pointed devices to operate the touch panel might result in damage of the touchscreen and display.

7.1.16 Printer

The thermal strip printer is for printing out measurement results. Do not print without paper.

7.1.17 Mains Connector

Plug receptacle for connecting the mains power.

7.1.18 Mains Fuses Box

Box containing the two fuses which protect the mains input. For replacement of the fuses see chapter 16.2 Care and Maintenance.

7.1.19 Power Switch

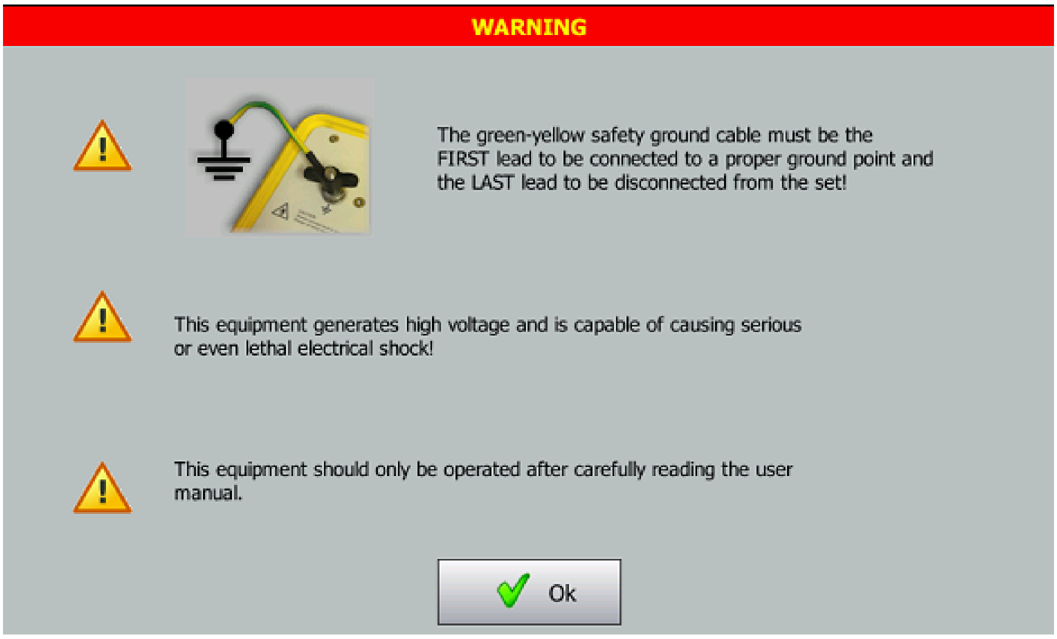
Switch to power up the device

⚠ **Always switch off the unit using the front power switch before connecting or removing the mains power cord.**

⚠ **The mains input must be connected to a suitably rated power source. The protective earth connection of the mains input must be connected to an appropriate protective earth, otherwise there is a safety risk for the operator.**

8 User interface

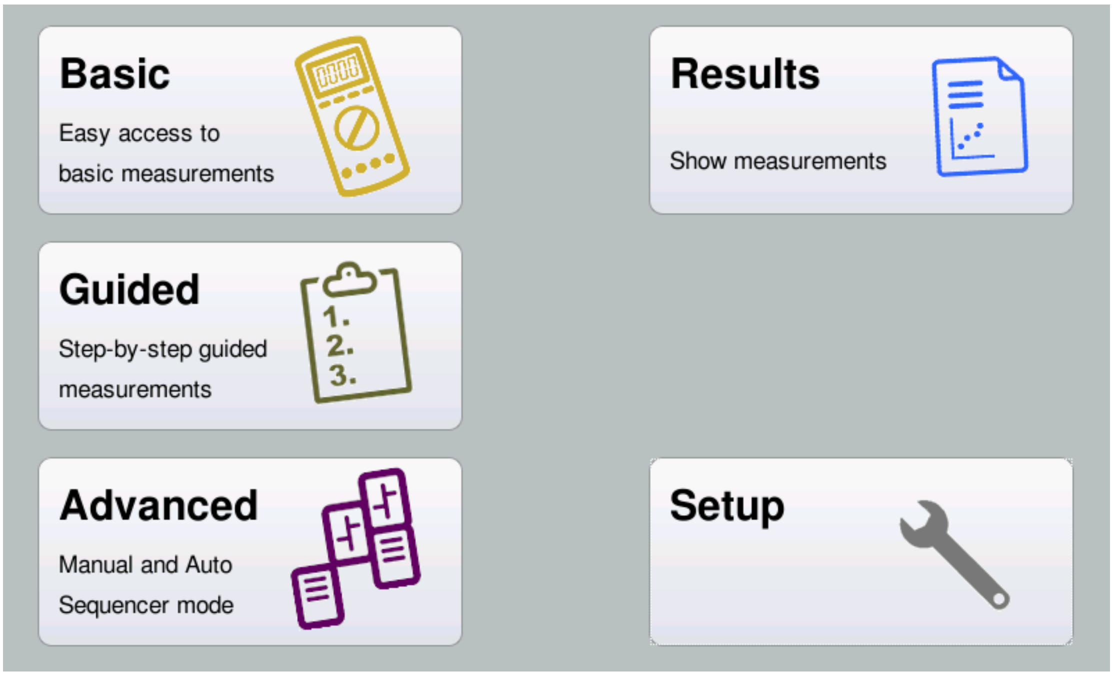
8.1 Startup Screen

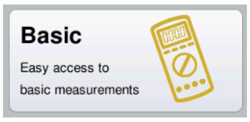
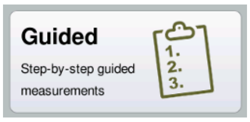
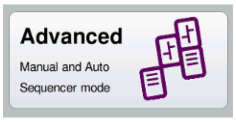
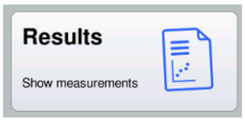


When starting up a warning screen is displayed to remind the user of the most important safety instructions. Read the warnings on the screen carefully and make sure you understand them. Confirm by clicking Ok.

8.2 Homescreen

The Home Screen is the starting point for the Midas micro 2883 software. From here you can select all the different measurement modes as well as the Results and Setup Screens. The table below provides a short overview of the options. In the following chapters each one of this modes and screens is explained in more detail.

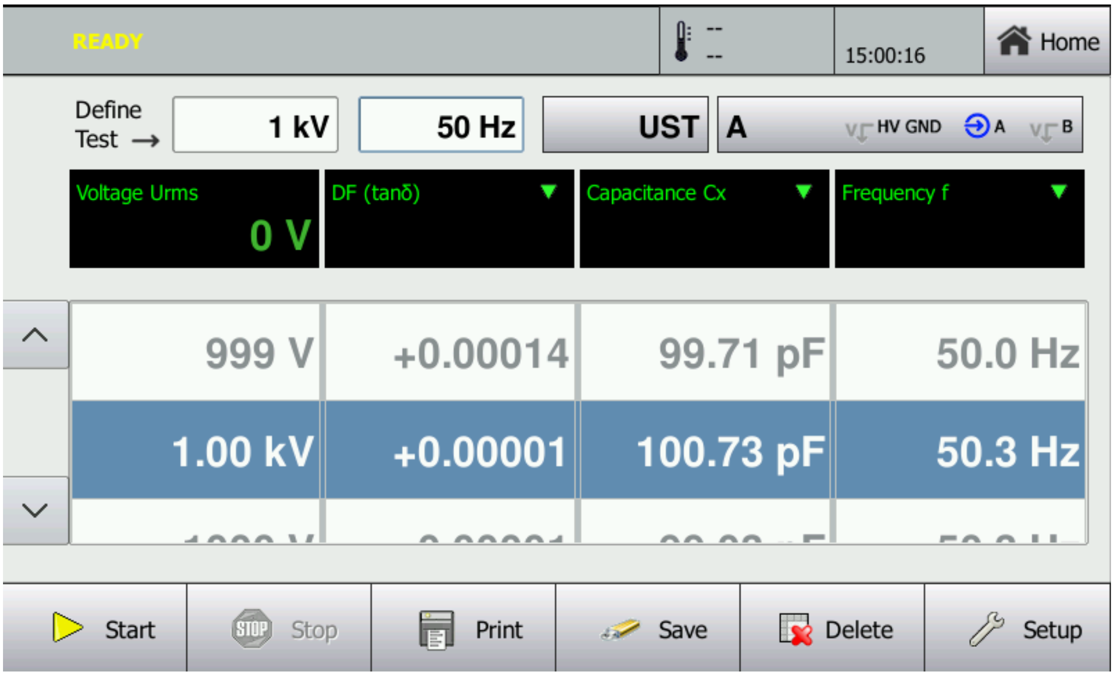


	**Basic Mode** Used for simple and fast manual measurements
	**Guided Mode** A wizard leads you through the setup of the measurement (selection of the type of DUT as well as the selection of the type of measurements you want to perform). An automated sequence is generated which guides the user through the steps of the measurement with instructions how to connect the DUT.
	**Advanced Mode** Advanced Mode allows you to edit custom automated sequences or to perform advanced manual measurements.
	**Results Screen** On the results screen you can open and analyze the recorded data, draw plots and print out data.
	**Call Setup Screen** The setup button leads to the setup screen.

9 Basic Mode

The basic mode provides simple and direct measurement. The complexity is reduced, leaving just the basic functionality. It is the best way to perform a fast and straight to the point measurement. For more complex or automated measurements the Advanced mode is recommend. For assisted measurement the Guided Mode is recommended..

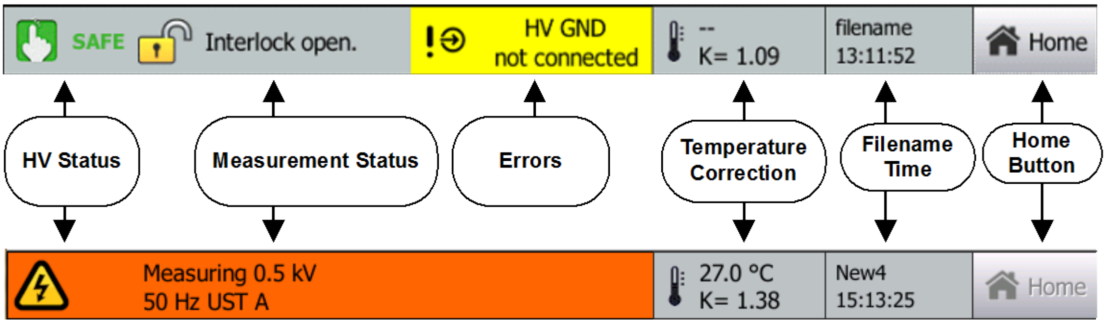
9.1 Basic Mode Screen



The basic mode screen can be seen above. A test begins with the definition of the parameters. When starting a measurement the Midas micro 2883 will source high voltage to the DUT with the values set in the test definition area. As soon as a stable and valid value has been measured, the measurement will be added to the measured values area and high voltage will be turned off. The toolbar gives the user multiple options to process the data. In the following chapters the different areas of the basic mode screen are explained in further detail.

9.1.1 Status Bar

The status bar is common to all measurement modes. It informs the user about the safety status of the device. Information about the current file, time and the temperature correction are also displayed.

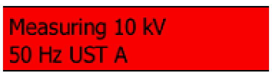
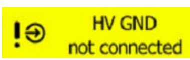


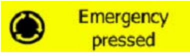
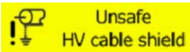
HV Status

The HV status informs the user if the high voltage is on, and if there is any danger for electrical shock.

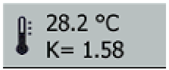
	**Safe** High voltage output is short-circuited. No danger from the device.
	**Ready** Device is ready to start high voltage output. No warnings or errors are present. Pressing the start button will turn on high voltage. Do not touch any parts that may be under high voltage, because one action will start up high voltage. **Caution: High Voltage possible anytime! The system is ready to switch high voltage on anytime. You have only to press the “Start” button to switch high voltage on.**
	High Voltage ON **Warning: High Voltage is live!** **The High Voltage is switched ON and active. Never attempt to disconnect the high voltage test cable or the low voltage lead(s) from either the terminals of the test specimen to which they are connected at the outboard end, or from the receptacles on the instrument at the inboard end. Attempts to disconnect leads while the MIDAS micro 2883 is energized may result in a serious and possibly lethal electrical shock.**

Measurement Status, Errors and Warnings

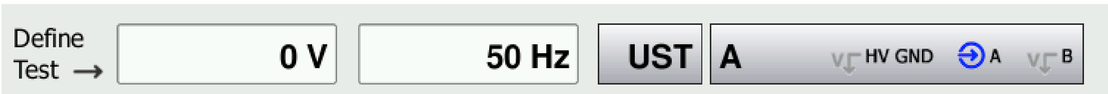
	**Measurement Information** Informs the user about the voltage, frequency and connection which is currently measured
	**Interlock Open** The Interlock open status indicates, that either the handheld device or the foot switch (whichever is used) is not pressed at the moment, preventing the user from starting high voltage output.
	**HV GND not connected** The HV GND input is not connected to power ground. This check guarantees that there is always a low-resistance connection between high voltage ground

	and power ground.
	**Emergency pressed** This warning indicates that the Emergency Stop Button has been pressed and needs to be released in order to turn on high voltage. Turn the Emergency Stop Button clock wise to release it.
	**Overheated** This warning indicates that the internal transformer's temperature has risen above the security shutoff temperature. In order to guarantee safety and integrity, the transformer temperature is monitored and the use of high voltage is restricted, when the internal transformer gets too hot.
	**Unsafe HV cable shield** This error indicates that an internal connection of the high voltage ground cables is broken. Use of the device under these conditions could be harmful and is therefore prevented.

Other Elements in the Status Bar

	**Temperature Correction** The upper line indicates the current temperature of the DUT. This can be a measured value using the temperature probe or a value entered manually in the DUT setup. The second line shows the correction factor considered for the calculation of the tan δ / DF / PF at 20°C. This factor depends on the temperature and the type of DUT selected in the setup.
	**Filename and Time** In the upper line the name of the current file is displayed. If the file has been changed since the last time it has been saved the filename will be displayed in yellow. The second line indicates the current time of day.
	**Home Button** Leads the user back to the home screen.

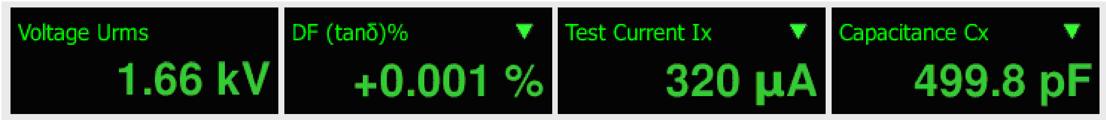
9.1.2 Test Definition Area



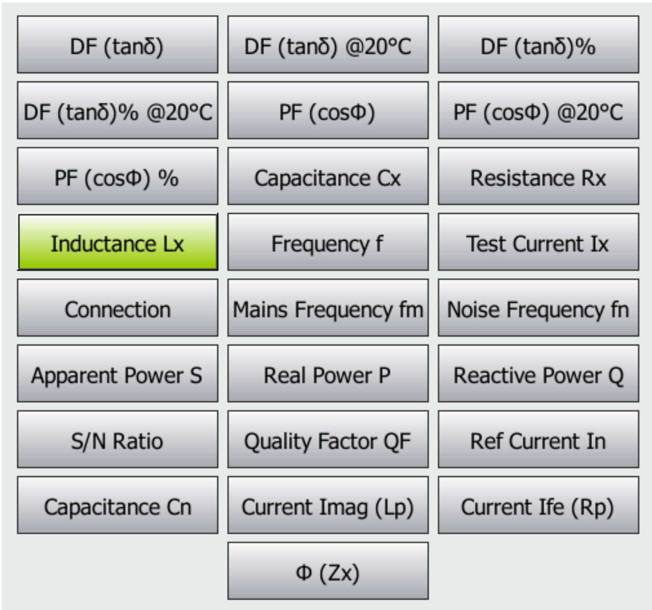
	**Test voltage** Select the test voltage
	**Test frequency** Select the test frequency
	**Grounded/Ungrounded Measurement** Select if you want to measure a grounded (GST) or ungrounded (UST) specimen. See chapter 6.3 Test Modes for a detailed description of the different test modes.

	**Channel selection** Select which channel(s) should be measured. The right part indicates how the measurement inputs are connected internally. Coloured symbols mean the input is connected to measurement. Greyed out V symbols mean the input is short-circuited to high voltage ground (guarded).

9.1.3 Measurement Bar and Displays



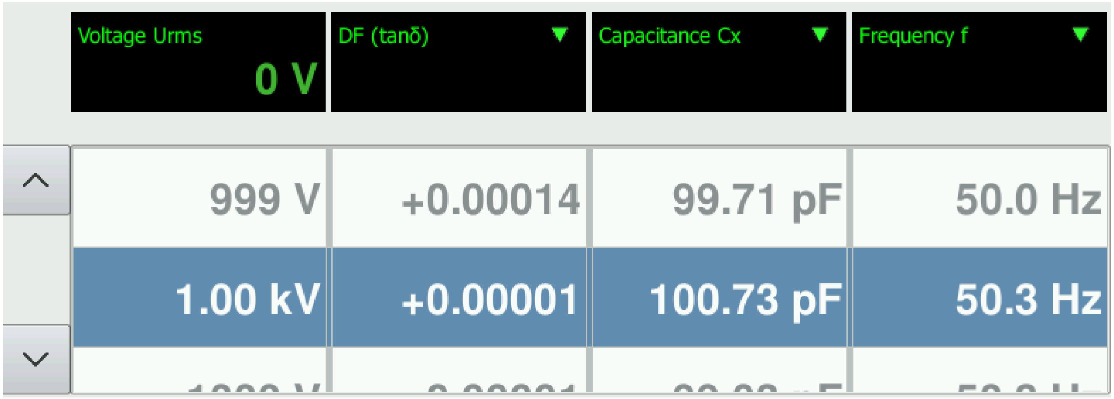
The measurement bar shows the actual measurement displays. The first display is always indicating the voltage on the high voltage output. The other three displays can be configured by the user. The values can be changed by clicking on the display. The user is then presented with a selection of measurement values. For further information about the measurement values see chapter 14 Measurement Values:



If small progress bars appear in the measurement display, this indicates that interference suppression is active. See chapter 6.4

Interference .

9.1.4 Recorded Measurements

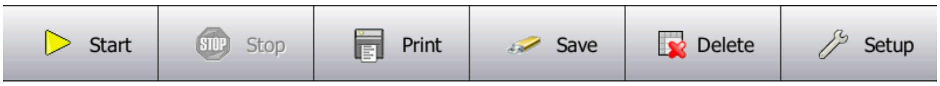


The area below the four measurement displays shows the recorded measurement data. The column values are corresponding to the measurement display selection. By changing the measurement display, the values in this area will be displayed accordingly. The arrows on the left side allow moving up and down the listing of measurements. The most recent measurement is listed at the top of the list.

9.1.5 Special Symbols in Measurement Values

Symbol	Explanation
r	Stands for reduced voltage. Occurs when the desired voltage cannot be reached because of one of the following reasons: No Signal at Cx → The voltage is limited to 5 kV in order to prevent high voltages when cables are not connected correctly. Voltage is limited over frequency. The full 12kV are only available between 40 and 75Hz. See chapter 3 Technical Data for more details. Voltage is limited when the output current is higher than 180mA.
~	Stands for reduced accuracy. Occurs when a measurement was performed in very difficult conditions (i.e. very low signal over noise ratio). The swung dash indicates that the specified accuracy cannot be guaranteed for this measurement value.
*	The star indicates that the stray capacitance compensation was active during the tagged measurement.

9.1.6 Toolbar Controls



The toolbar in Basic Mode

The toolbar provides quick access to the most important features of the Midas micro 2883 basic mode.

	**Start Button** Starts the measurement with the parameters set in the test definition bar. When pressing this button high voltage will be turned on. Only active when no warnings or errors are present.
	**Stop Button** Stops the current measurement and turns high voltage off. Only active when high voltage is turned on. Only needed to abort a test. High voltage turns off automatically when a measurement is completed.
	**Print Results**

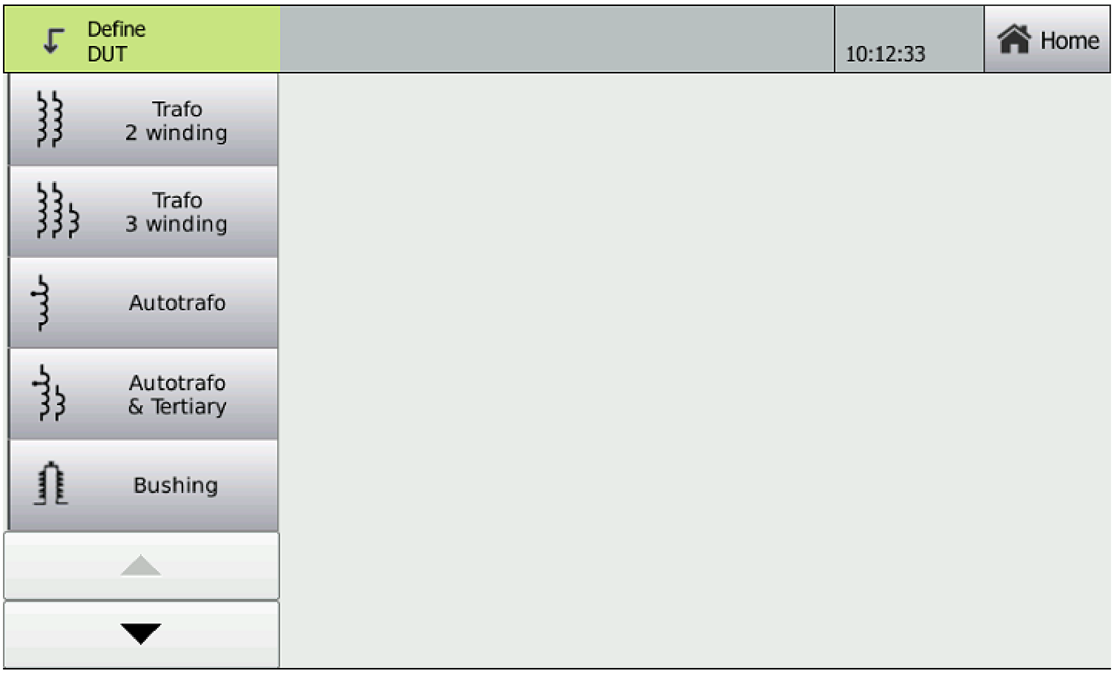
	Prints out the selected rows of the measurement data window. Note: the header on the print out is only printed the first time.
	**Save File** Saves a file containing all the data displayed in the measuring data window on a USB stick under a name selected by the user.
	**Delete Measurements** Deletes all measurements recorded.
	**Setup** Calls the Setup screen where you can define the DUT and change preferences and settings. See chapter 12 Setup.

10 Guided Mode

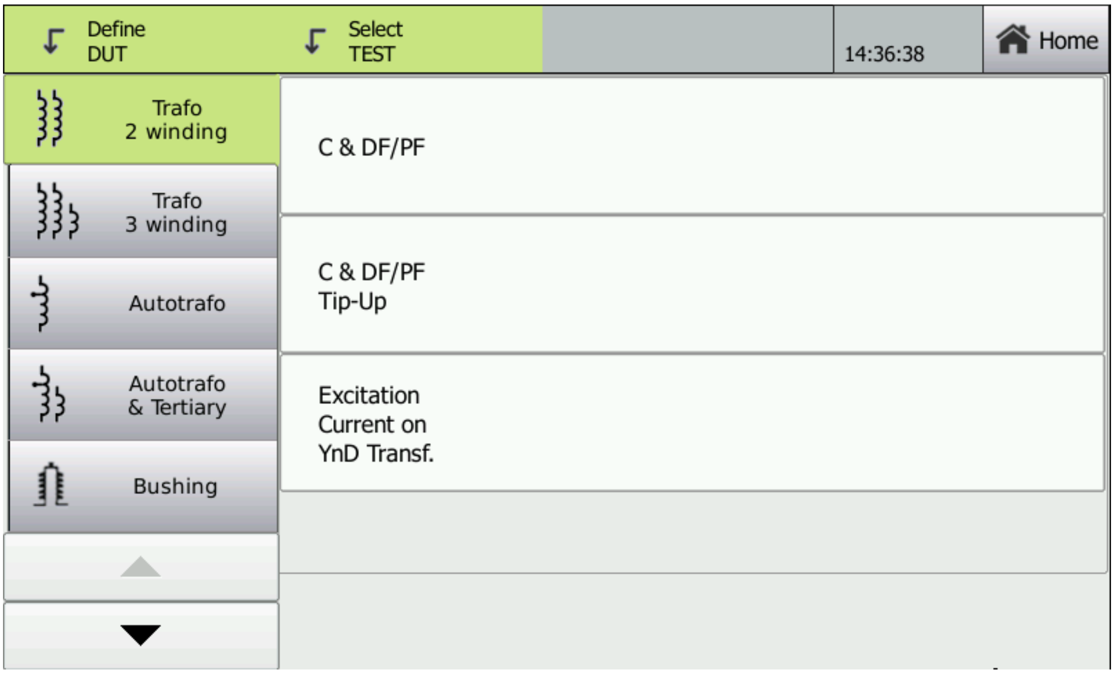
The guided mode provides extended assistance in setting up a test. The user is guided through the selection of all relevant test parameters as well as through the test itself. Instruction screens are shown to help with the connections. All the common test devices are supported in Midas micro 2883 software. This is the best mode for users who want to make quick and correct measurements, without having to obtain in-depth knowledge of the functionality of tan delta measurement. The guide leads you step by step through test definition as described in the following sub-chapters.

10.1 DUT and Test selection

10.1.1 Define Test Parameters



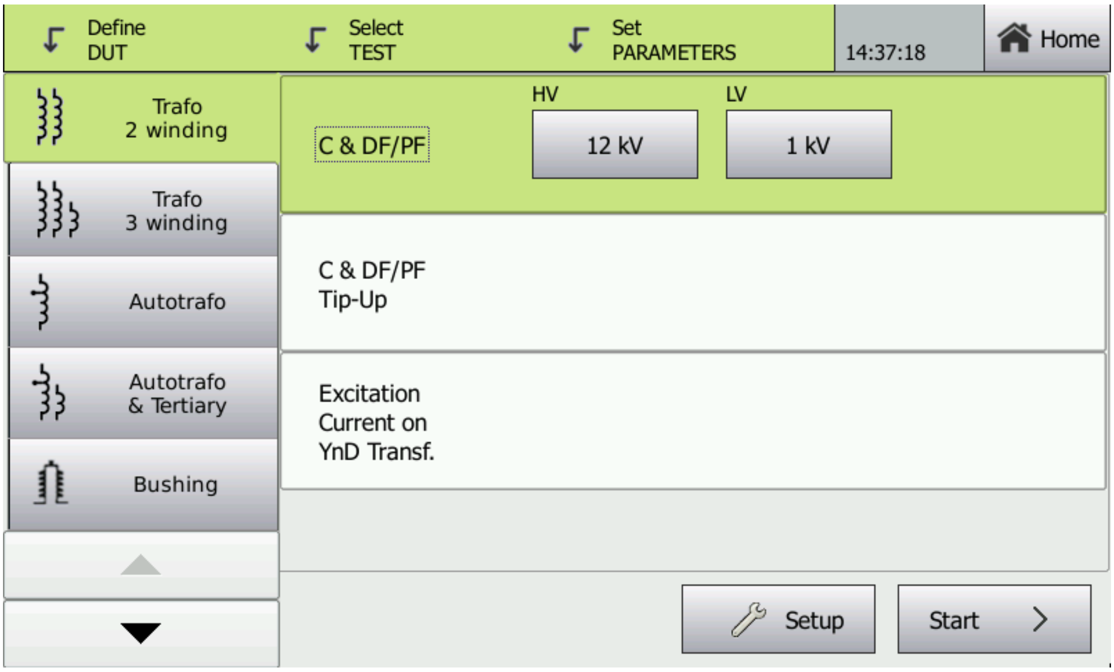
In the first step select the type of DUT you want to perform the measurements on. Use the arrows to scroll through the options. If you cannot find the type of device you wish to test in the list, please contact support@tettex.ch. See chapter 20 Applications Guide to see more detailed description of the supported types of DUT.



In the next step the desired test is selected. For each type of DUT there are predefined tests available which cover the most common tests for the selected test objet. Select a test.

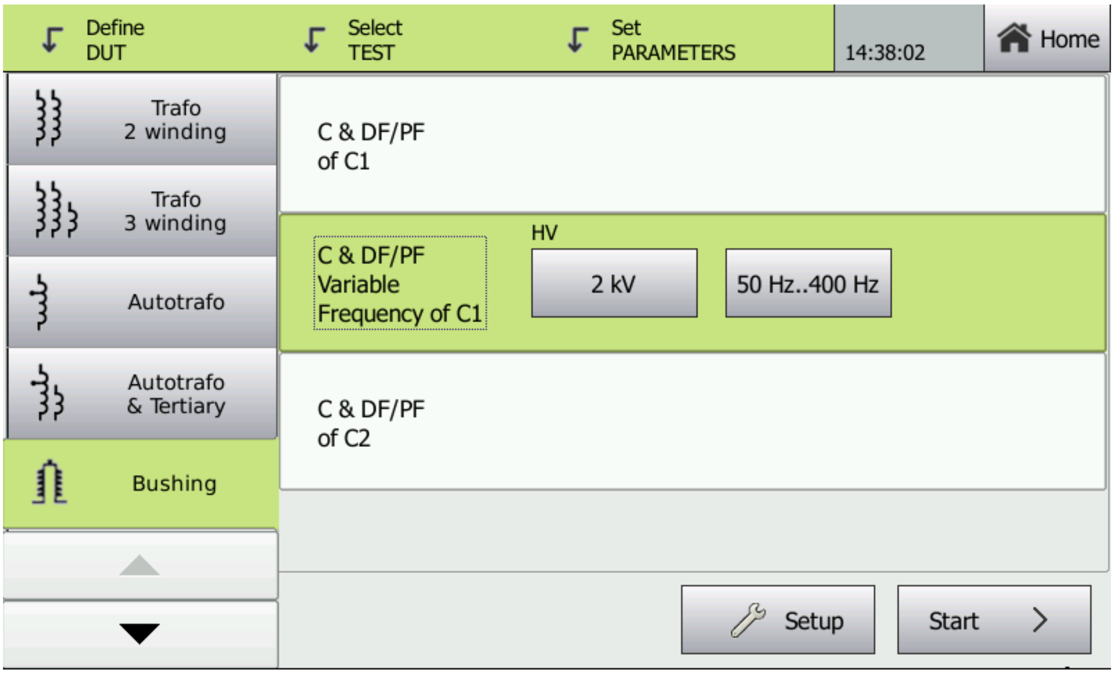
Not all possible tests are available for every type of DUT. In order to keep the choice more clear, only the commonly used tests for each type of DUT are implemented. If you are missing a specific test please inform us at support@tettex.com. If you want complete freedom of test definition please use advanced mode.

In the next step the test parameters are defined.

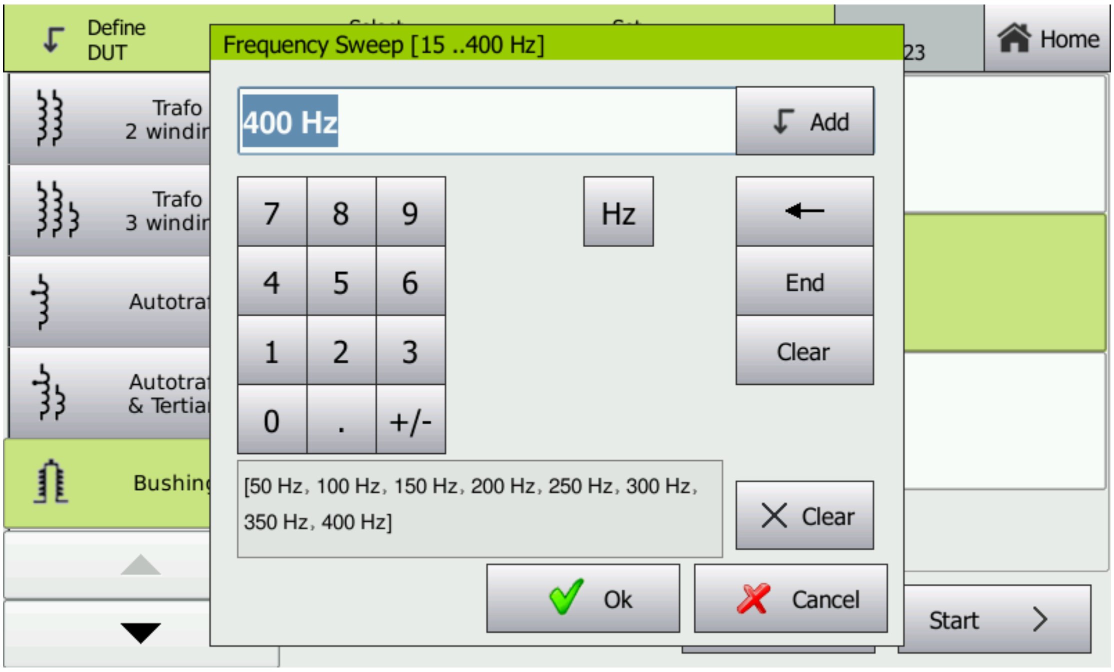


You can now determine the voltages you want to apply for measurement. If there is more than one winding where the HV will be applied during the test, you have to select the test voltage for every winding. Make sure the test voltages are within the rated values of the corresponding windings.

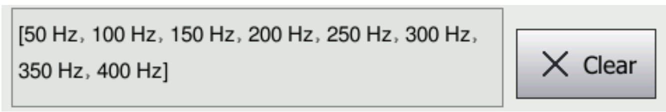
Example: If the HV side of a transformer is rated 36 kV and the LV winding is rated 2 kV, you can chose whatever voltage you like for the HV side. When connecting to the LV winding you have to select voltages <= 2 kV.



Sometimes more than one parameter is selectable. On the image above you can select the test voltage, as well as the test frequencies. The dots in the Frequencies field show that more than one value has been selected. Click on the button to edit these values.

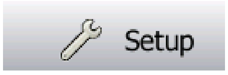
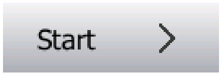


The dialog above will open up. The following text field shows the selected frequencies.



By entering a value in the top line using the on screen keyboard and then clicking on the Add button, a new test point will be added at the end of the list. You can clear the whole list by clicking on the Clear Button. Once all the desired measurement points are in the list, the selection can be confirmed by clicking on the Ok Button.

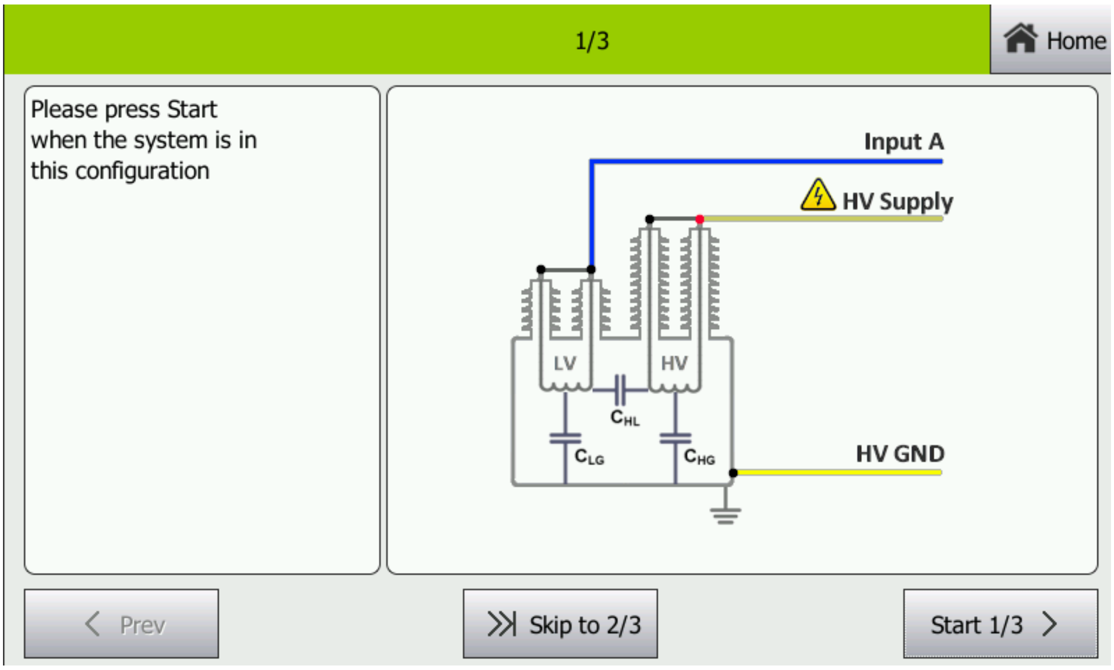
The procedure for the selection of multiple voltage measuring points is identical.

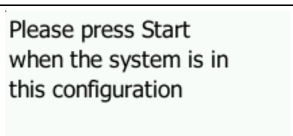
	**Setup Button** Leads to the Setup screen, described in chapter 12 Setup. This is mainly used to define the characteristics of the DUT (type, serial number, etc.)
	**Start Button** The Start Button sets up the test with the given parameters and leads to the first Instruction Screen.

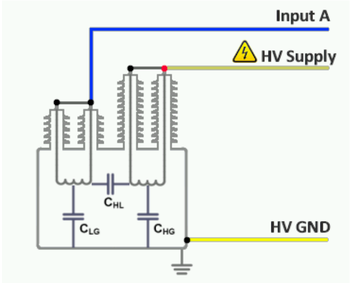
10.2 Instruction Screen

Every time the connection has to be changed an instruction screen appears. Connect all the cables accordingly and click Start.

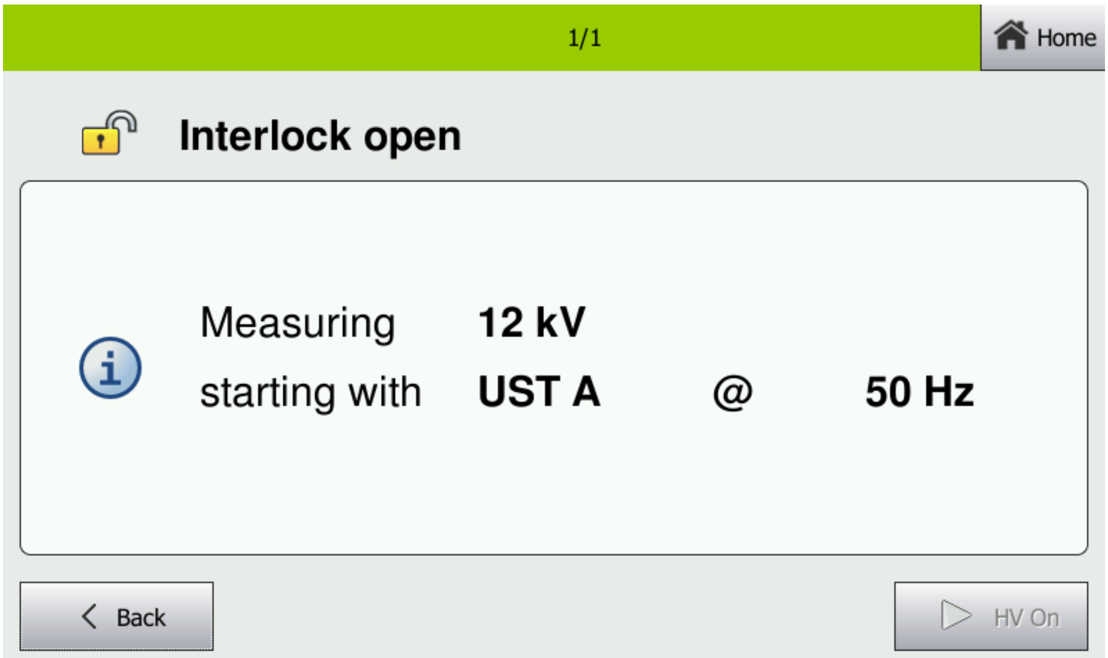
Depending on the test performed, the number of steps changes. After each step another instruction screen appears.



	**Instructions** Follow the instructions given in the textbox to the left

	**Connection schematic** Connect the measuring cables and the HV supply cable as shown on the image. Do not forget to use proper grounding as the earthing cable is not shown in the schematic.
1/3	**Progress** Shows the progress of the measurement.
Skip to 2/3	**Skip Button** With the skip button you can skip one of the steps. This can be helpful if you want to measure only part of a DUT without running the whole test.
Prev 1/3	**Previous Button** With that button you can go back one step in the measurement sequence.
Start 1/3	**Start Button** This button will start the measurement step currently described on the display. This leads to the measurement start screen described in the next chapter, where the high voltage can be turned on.

10.3 Measurement Start Screen

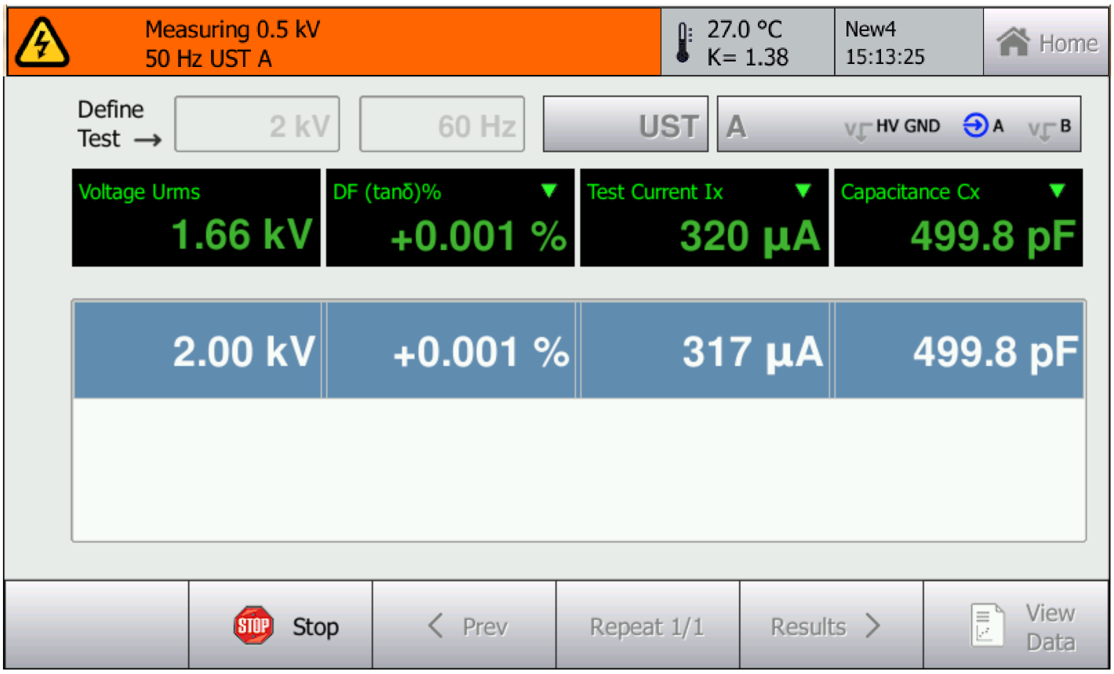


Before the measurement can be started the measurement start screen informs the user about the measurement which will be performed. Also the pending warning and error messages are displayed here. As soon as no warnings or errors are present the measurement can be started. The table below explains the different warnings and errors.

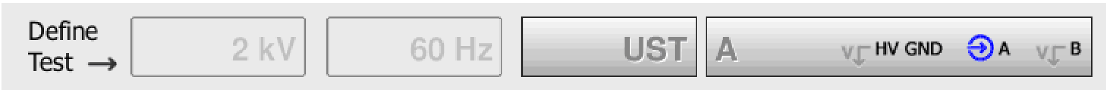
Measuring 12 kV starting with UST A @ 50 Hz	**Measuring Information** Information about the measurement which is about to be performed. Voltage, test mode and frequency are indicated.
Interlock open EMERGENCY pressed HV Supply overheated HV GND not connected Unsafe HV cable shield	**Warnings and Errors** The warnings and errors indicate why the measurement cannot start. As a result the HV on button will be greyed out as long as a warning is present. **Interlock open** Handheld / Footswitch is not pressed. **Emergency Button** Emergency button has been pressed. Release Emergency button by turning it in the indicated direction. **HV supply overheated** If maximum output current is sourced for a long period the internal HV source may heat up. In order to protect the device from damage the Midas micro 2883 comes with an overheat protection. Please wait until the HV source has cooled down and retry. **HV GND not connected** The HV GND measuring probe is not connected to ground. Make sure the HV GND probe is connected to ground and that the device is properly grounded. **Unsafe HV cable shield** This is an error condition. If the internal connection of the high voltage ground is broken no safe measurement is possible. Please do not further use the instrument and contact support@tettex.com
HV On	**HV On Button** Press HV On to initiate test.
Back	**Back Button** Go back to instruction screen
Home	**Home Button** Go back to home screen

10.4 The measurement screen

During the measurement the screen looks like shown below. The screen is composed of the status bar, the test definition bar below, the measured values area and the tool bar. All these areas are described in the following chapters.



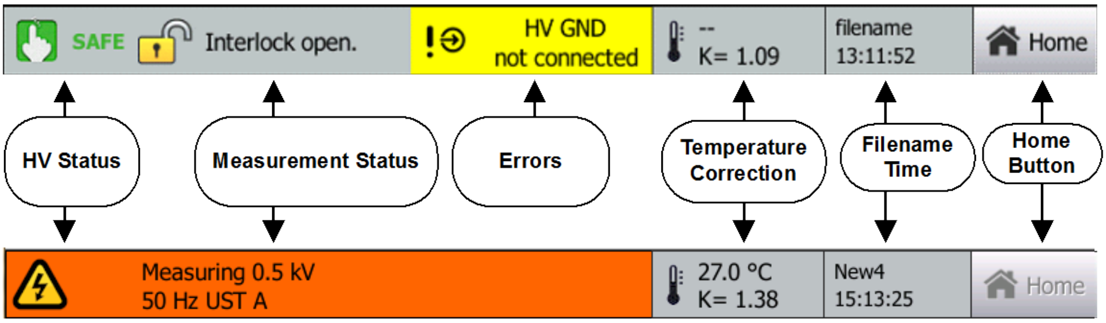
The test definition bar shows the parameters of the actual measurement. These parameters are set according to the test setup by the wizard. Therefore they cannot be changed during measurement.



The Stop Button in the toolbar is only available when high voltage is turned on. It allows switching off high voltage and interrupting the test sequence. By pressing the stop button the user will be automatically returned to the instruction screen.

10.4.1 Status Bar

The status bar is common to all measurement modes. It informs the user about the safety status of the device. Information about the current file, time and the temperature correction are also displayed.

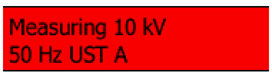


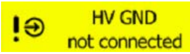
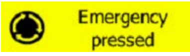
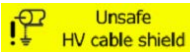
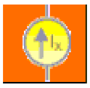
HV Status

The HV status informs the user if the high voltage is on, and if there is any danger for electrical shock.

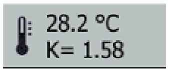
	**Safe** High voltage output is short-circuited. No danger from the device.
	**Ready** Device is ready to start high voltage output. No warnings or errors are present. Pressing the start button will turn on high voltage. Do not touch any parts that may be under high voltage, because one action will start up high voltage.  **Caution: High Voltage possible anytime! The system is ready to switch high voltage on anytime. You have only to press the "Start" button to switch high voltage on.**
	**High Voltage ON**  **Warning: High Voltage is live!** **The High Voltage is switched ON and active. Never attempt to disconnect the high voltage test cable or the low voltage lead(s) from either the terminals of the test specimen to which they are connected at the outboard end, or from the receptacles on the instrument at the inboard end. Attempts to disconnect leads while the MIDAS micro 2883 is energized may result in a serious and possibly lethal electrical shock.**

Measurement Status, Errors and Warnings

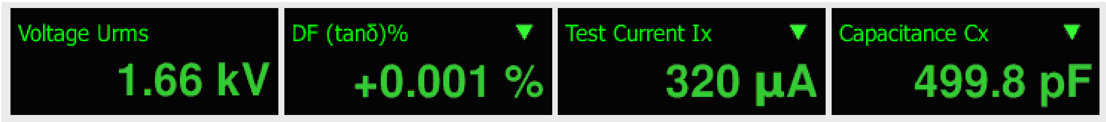
	**Measurement Information** Informs the user about the voltage, frequency and connection which is currently measured
	**Interlock Open** The Interlock open status indicates, that either the handheld device or the foot switch (whichever is used) is not pressed at the moment, preventing the user from starting high voltage output.

	**HV GND not connected** The HV GND input is not connected to power ground. This check guarantees that there is always a low-resistance connection between high voltage ground and power ground.
	**Emergency pressed** This warning indicates that the Emergency Stop Button has been pressed and needs to be released in order to turn on high voltage. Turn the Emergency Stop Button clock wise to release it.
	**Overheated** This warning indicates that the internal transformer's temperature has risen above the security shutoff temperature. In order to guarantee safety and integrity, the transformer temperature is monitored and the use of high voltage is restricted, when the internal transformer gets too hot.
	**Unsafe HV cable shield** This error indicates that an internal connection of the high voltage ground cables is broken. Use of the device under these conditions could be harmful and is therefore prevented.
	**Excitation Mode active** This symbol shows, that excitation mode is active. In this mode regulation and stability criteria will be based on the measured current and not on the voltage and dissipation factor. See also 12.3.1.

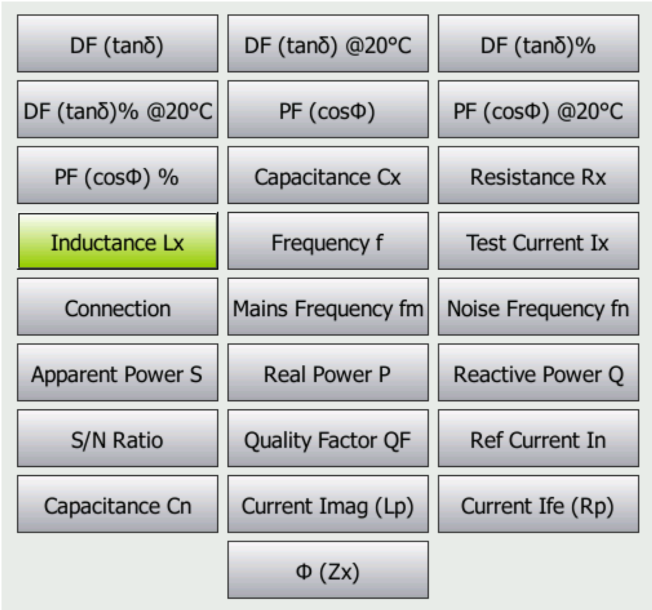
Other Elements in the Status Bar

	**Temperature Correction** The upper line indicates the current temperature of the DUT. This can be a measured value using the temperature probe or a value entered manually in the DUT setup. The second line shows the correction factor considered for the calculation of the tan δ / DF / PF at 20°C. This factor depends on the temperature and the type of DUT selected in the setup.
	**Filename and Time** In the upper line the name of the current file is displayed. If the file has been changed since the last time it has been saved the filename will be displayed in yellow. The second line indicates the current time of day.
	**Home Button** Leads the user back to the home screen.
	**Channel selection** Select which channel(s) should be measured. The right part indicates how the measurement inputs are connected internally. Coloured symbols mean the input is connected to measurement. Greyed out V symbols mean the input is short-circuited to high voltage ground (guarded).

10.4.2 Measurement Bar and Displays

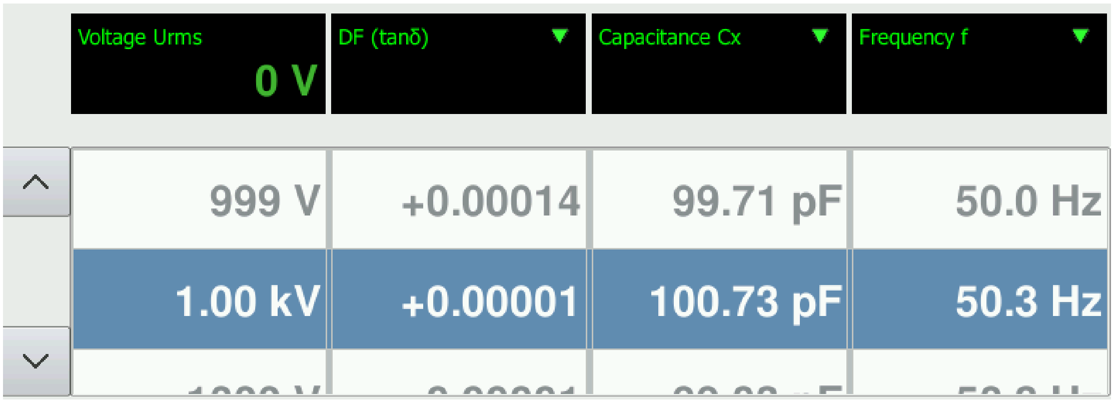


The measurement bar shows the actual measurement displays. The first display is always indicating the voltage on the high voltage output. The other three displays can be configured by the user. The values can be changed by clicking on the display. The user is then presented with a selection of measurement values. For further information about the measurement values see chapter 14 Measurement Values:



If small progress bars appear in the measurement display, this indicates that interference suppression is active. See chapter 6.4.

10.4.3 Recorded Measurements



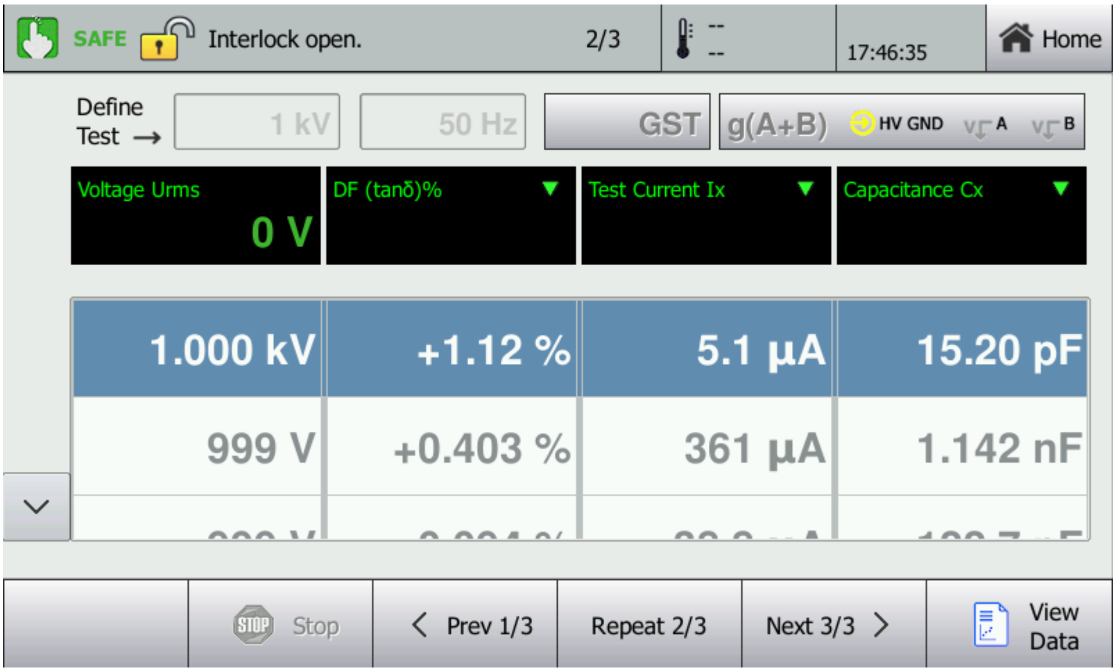
The area below the four measurement displays shows the recorded measurement data. The column values are corresponding to the measurement display selection. By changing the measurement display, the values in this area will be displayed accordingly. The arrows on the left side allow moving up and down the listing of measurements. The most recent measurement is listed at the top of the list.

10.4.4 Special Symbols in Measurement Values

Symbol	Explanation
r	Stands for reduced voltage. Occurs when the desired voltage cannot be reached because of one of the following reasons: No Signal at Cx → The voltage is limited to 5 kV in order to prevent high voltages when cables are not connected correctly. Voltage is limited over frequency. The full 12kV are only available between 40 and 75Hz. See chapter 3 Technical Data for more details. Voltage is limited when the output current is higher than 180mA.
~	Stands for reduced accuracy. Occurs when a measurement was performed in very difficult conditions (i.e. very low signal over noise ratio). The swung dash indicates that the specified accuracy cannot be guaranteed for this measurement value.
*	The star indicates that the stray capacitance compensation was active during the tagged measurement.

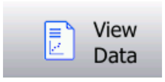
10.4.5 Toolbar

Every time a step is completed the user will be informed by a dialog. The user can then decide how to continue measurement using the toolbar.



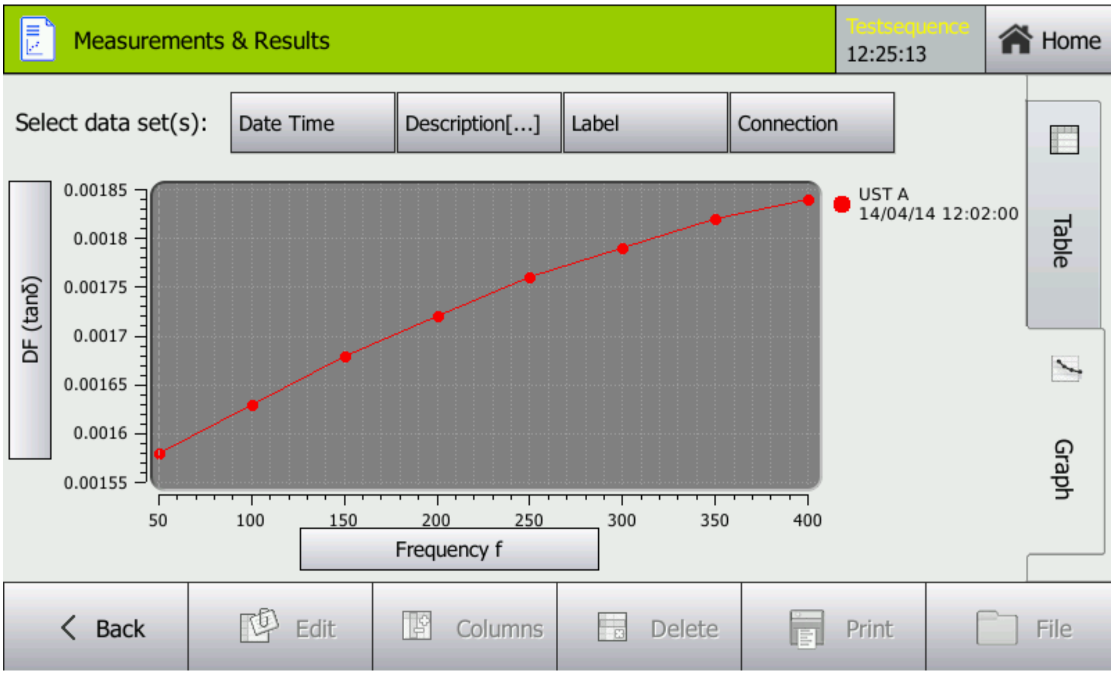
The toolbar allows the user to move forward or backward in the sequence or to review the measured values. The table below describes the different options in detail.

Prev 1/3	**Previous Step** Leads to the previous step.
Repeat 2/3	**Repeat Step** Repeats the measurement of the actual step.
Next 3/3 Results	**Next Step / Results** If there are more steps to be completed in the measurement sequence, then the button "Next" continues the measurement by going to the next step If the last step has been completed, then a Results button will appear. This button leads to the final Results screen.

	From the final results screen you can no longer step backward or repeat steps. Use view data instead if you want to check measurement values before finalizing the measurement.
	**View Data** Leads to a the results screen with the actual measurements. The functionality is similar to the result screen, as described in chapter 13 Results Screen, except that the file menu is not available.

10.5 The Results Screen

The final screen is the results screen. Here the results can be analyzed, printed and saved. For a detailed description of the Results Screen see chapter 13 Results Screen. To leave the measurement, press the home button. Don't forget to save your data first.

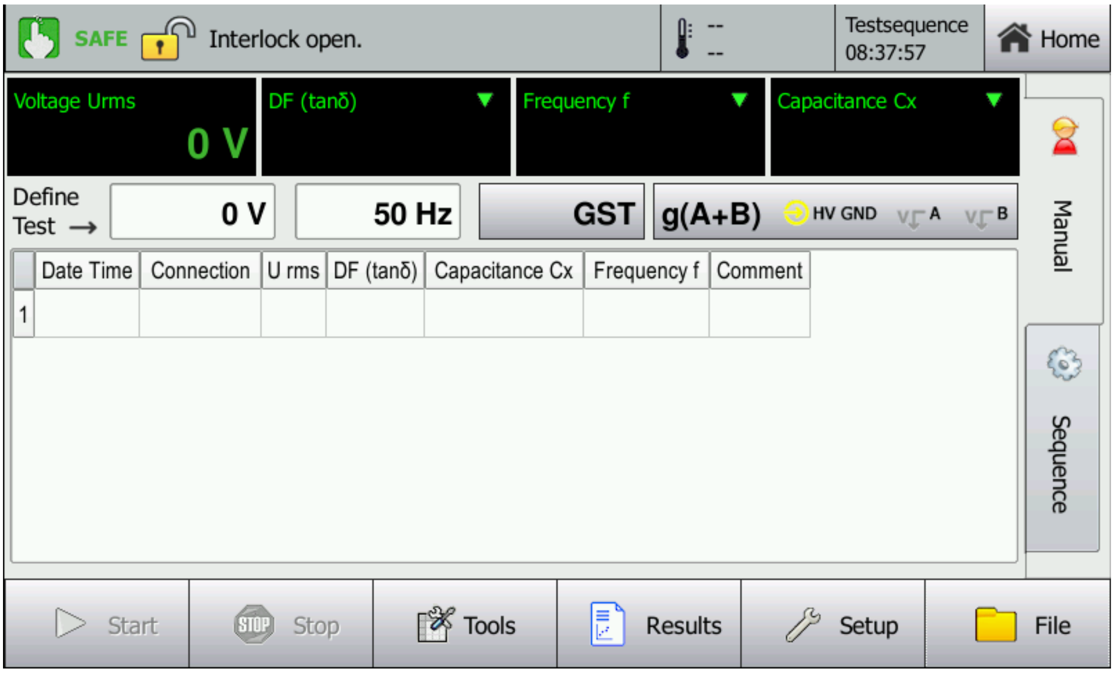


11 Advanced Mode

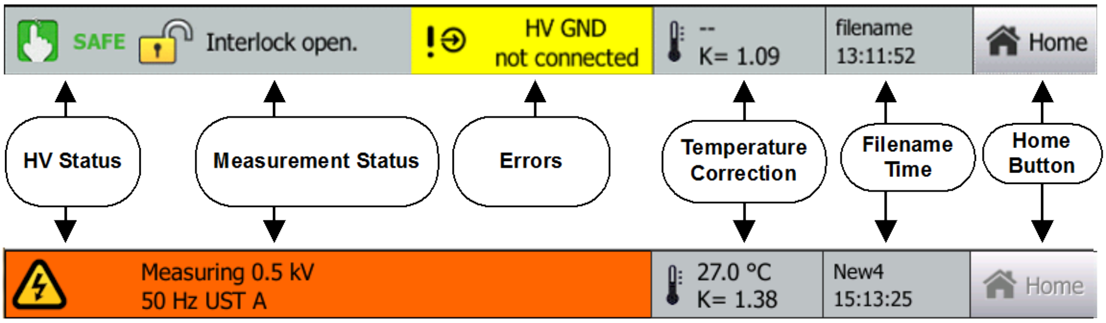
The advanced mode gives the user all the options and freedom to measure manually or to create custom sequences to perform automated measurement. It addresses expert users with the need for complete freedom of choice for the parameterisation of their measurements.

11.1 Manual Tab

The manual tab allows the user to perform simple manual measurements, similar to basic mode. First the test parameters are defined, then high voltage is turned on and a measurement value is recorded. The manual tab does also list all the measurement values recorded in the current file.



The status bar is common to all measurement modes. It informs the user about the safety status of the device. Information about the current file, time and the temperature correction are also displayed.

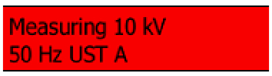
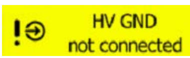


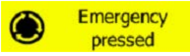
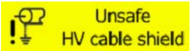
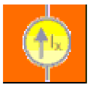
HV Status

The HV status informs the user if the high voltage is on, and if there is any danger for electrical shock.

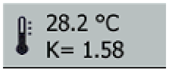
	**Safe** High voltage output is short-circuited. No danger from the device.
	**Ready** Device is ready to start high voltage output. No warnings or errors are present. Pressing the start button will turn on high voltage. Do not touch any parts that may be under high voltage, because one action will start up high voltage. **Caution: High Voltage possible anytime! The system is ready to switch high voltage on anytime. You have only to press the “Start” button to switch high voltage on.**
	**High Voltage ON** **Warning: High Voltage is live!** **The High Voltage is switched ON and active. Never attempt to disconnect the high voltage test cable or the low voltage lead(s) from either the terminals of the test specimen to which they are connected at the outboard end, or from the receptacles on the instrument at the inboard end. Attempts to disconnect leads while the MIDAS micro 2883 is energized may result in a serious and possibly lethal electrical shock.**

Measurement Status, Errors and Warnings

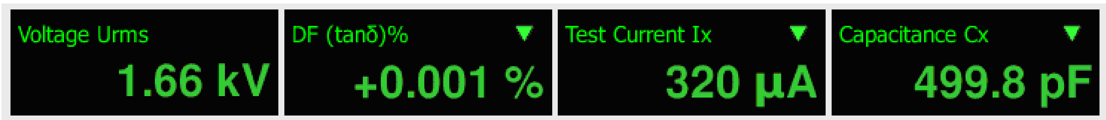
	**Measurement Information** Informs the user about the voltage, frequency and connection which is currently measured
	**Interlock Open** The Interlock open status indicates, that either the handheld device or the foot switch (whichever is used) is not pressed at the moment, preventing the user from starting high voltage output.
	**HV GND not connected** The HV GND input is not connected to power ground. This check guarantees that there is always a low-resistance connection between high voltage ground and power ground.

	**Emergency pressed** This warning indicates that the Emergency Stop Button has been pressed and needs to be released in order to turn on high voltage. Turn the Emergency Stop Button clock wise to release it.
	**Overheated** This warning indicates that the internal transformer's temperature has risen above the security shutoff temperature. In order to guarantee safety and integrity, the transformer temperature is monitored and the use of high voltage is restricted, when the internal transformer gets too hot.
	**Unsafe HV cable shield** This error indicates that an internal connection of the high voltage ground cables is broken. Use of the device under these conditions could be harmful and is therefore prevented.
	**Excitation Mode active** This symbol shows, that excitation mode is active. In this mode regulation and stability criteria will be based on the measured current and not on the voltage and dissipation factor. See also 12.3.1.

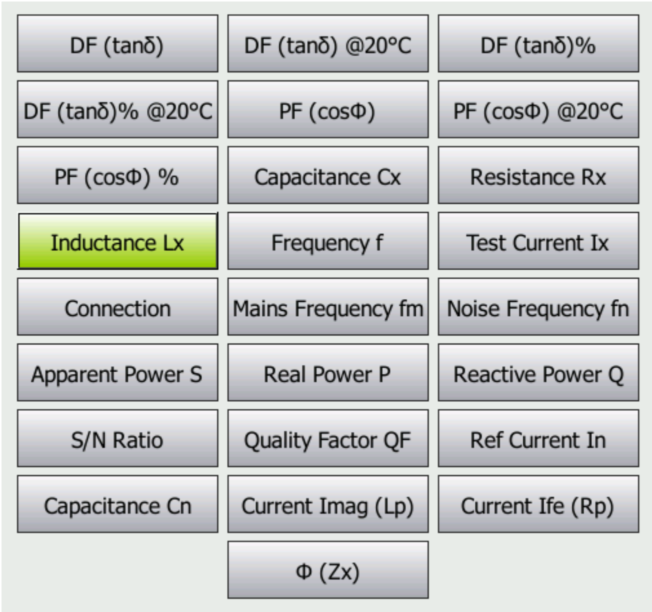
Other Elements in the Status Bar

	**Temperature Correction** The upper line indicates the current temperature of the DUT. This can be a measured value using the temperature probe or a value entered manually in the DUT setup. The second line shows the correction factor considered for the calculation of the tan δ / DF / PF at 20°C. This factor depends on the temperature and the type of DUT selected in the setup.
	**Filename and Time** In the upper line the name of the current file is displayed. If the file has been changed since the last time it has been saved the filename will be displayed in yellow. The second line indicates the current time of day.
	**Home Button** Leads the user back to the home screen.

11.1.1 Measurement Bar and Displays

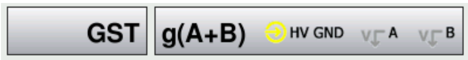


The measurement bar shows the actual measurement displays. The first display is always indicating the voltage on the high voltage output. The other three displays can be configured by the user. The values can be changed by clicking on the display. The user is then presented with a selection of measurement values. For further information about the measurement values see chapter 14 Measurement Values:



If small progress bars appear in the measurement display, this indicates that interference suppression is active. See chapter 6.4 Interference.

11.1.2 Test Settings

	**Connection Settings** Select the measuring mode (UST or GST) and the connection, you would like to measure.
	**Test Definition** Define Test voltage and frequency by entering the corresponding values in the text fields.

11.1.3 Measured Values Area

In this area all the measured values are displayed. The displayed columns can be selected with the select columns dialog. Scrollbars at the left side allow scrolling through the measurements.

	Date Time	Connection	U rms	DF (tanδ)%	Test Current Ix	Comment
1	23/05/14 11:04:10	UST A	2.002 kV	+0.0007 %	633.7 µA	--
2	23/05/14 11:05:17	UST A	2.003 kV	+0.0006 %	631.0 µA	--
3	23/05/14 11:05:44	UST A	1.999 kV	+0.0006 %	633.5 µA	--

11.1.4 Special Symbols in Measurement Values

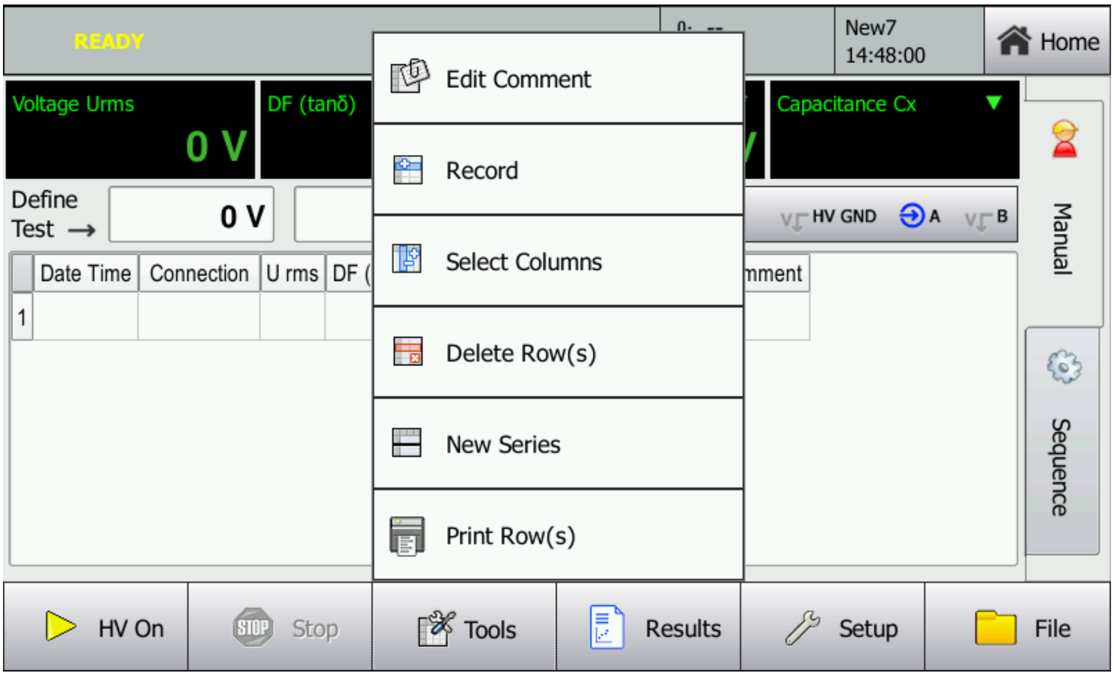
Symbol	Explanation
r	Stands for reduced voltage. Occurs when the desired voltage cannot be reached because of one of the following reasons: No Signal at Cx → The voltage is limited to 5 kV in order to prevent high voltages when cables are not connected correctly. Voltage is limited over frequency. The full 12kV are only available between 40 and 75Hz. See chapter 3 Technical Data for more details. Voltage is limited when the output current is higher than 180mA.
~	Stands for reduced accuracy. Occurs when a measurement was performed in very difficult conditions (i.e. very low signal over noise ratio). The swung dash indicates that the specified accuracy cannot be guaranteed for this measurement value.
*****	The star indicates that the stray capacitance compensation was active during the tagged measurement.
^	The caret or circumflex signals that a measurement value has been recorded in excitation current measuring mode. This means the value has been recorded when the current measurement was stable (not the DF value as usual).

11.1.5 Toolbar

	**Tools Button** Opens the tools menu with various options to edit the displayed measured values. See next chapter for more detailed information.
	**Results Button** Opens the Results Screen in order to visualize the results. See chapter 13 Results Screen.
	**Setup Button** Opens the setup menu with various device settings and options. See chapter 12 Setup for more detailed information.
	**File Button** Opens the file menu with various options to manipulate files in storage. See subchapter below for more detailed information.
	**Start Button** Starts the measurement with the parameters and connection defined in the test definition. This button is only available if no warning or error is active. Warnings and Errors are indicated in the status bar.
	**Stop Button** Stops the measurement and turns HV off. If "HV OFF after measurement" is active the high voltage will be switched off automatically and this button has only the function to abort a measurement early.

11.1.6 The Tools Menu

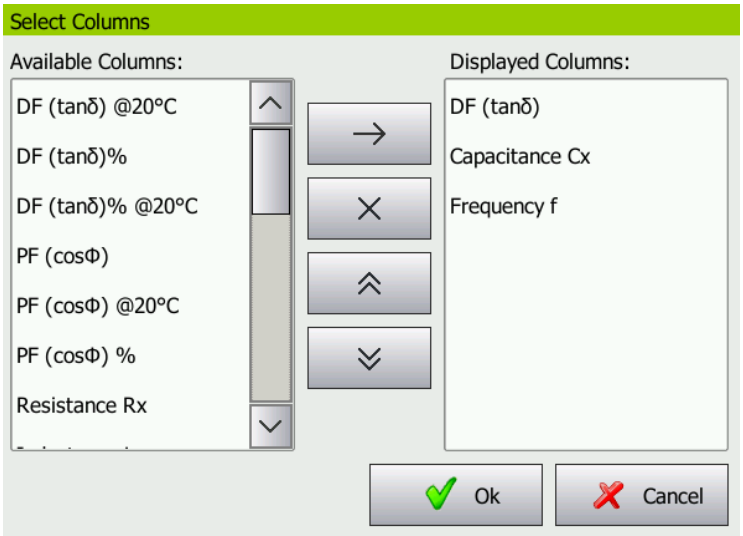
When clicking on the tools button, the tools menu appears:

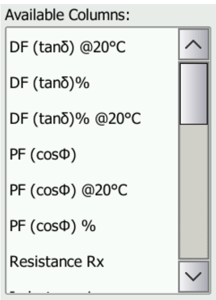
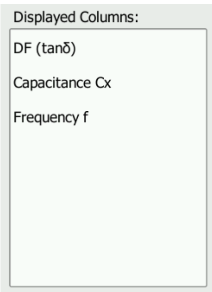
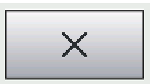


Below you can find a listing of all the options of the tools menu.

Edit Comment	**Edit Comment** Allows editing the text in the Comment column of the selected entry(s).
Record	**Record** Records manually the current measurement values. Normally the values are recorded automatically as soon as they are valid and stable. If the option “HV off after measurement” (see Setup→Miscellaneous Tab) is deactivated, you can manually record measurements by pressing this button.
Select Columns	**Select Columns** Allows the user to select which columns are displayed in the measurement display area. Opens up a dialog window which is described in the next subchapter in more detail.
Delete Row(s)	**Delete Row(s)** Deletes the selected row(s) in the measurement display area.
New Series	**New Series** Inserts an empty line in order to visually separate two measurement series.
Print Row(s)	**Print Row(s)** Prints the selected row(s) on the internal printer.

Select Columns Dialog



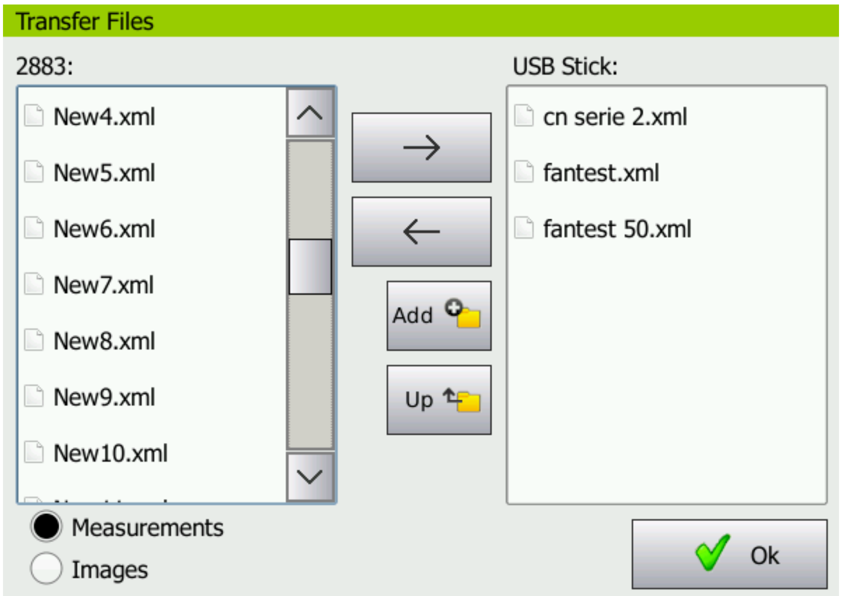
	**Available Columns** Lists all the available measurement values. You can select values by clicking on the text. For an explanation of each measurement value see chapter 14 Measurement Values.
	**Displayed Columns** Lists the measurement values which are displayed in the measurement display area. The higher an element is in the list, the more to the left it will be displayed.
	**Add Measurement category** Add the selected columns form the available columns to the displayed columns.
	**Remove Measurement category** Remove the selected columns from the displayed columns.
	**Change order** By using the arrows a measurement value can be moved up and down in the list. The higher a value is in the list, the more to the left it will be displayed in the measurement display window.

11.1.7 The File Menu

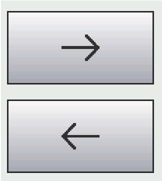
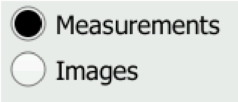
The internal file system of the Midas micro 2883 is an XML structure. If a measuring data transfer to the USB stick is performed the data are always exported in two formats: XML and CSV.
Due to clarity reasons only the XML files are visualized in the file list structures to keep the interface simple.

New	**New File** Creates a new, empty file.
Load	**Load File** Loads an existing file from the internal storage.
Save	**Save File** Saves the current file on the internal storage.
Save As	**Save File As** Saves the current file under a new name.
Delete	**Delete File** Allows deleting any measurement file on the internal storage.
USB Transfer	**USB Transfer** Allows transferring files from or to an external USB Drive. Opens up a transfer dialog window.

USB Transfer

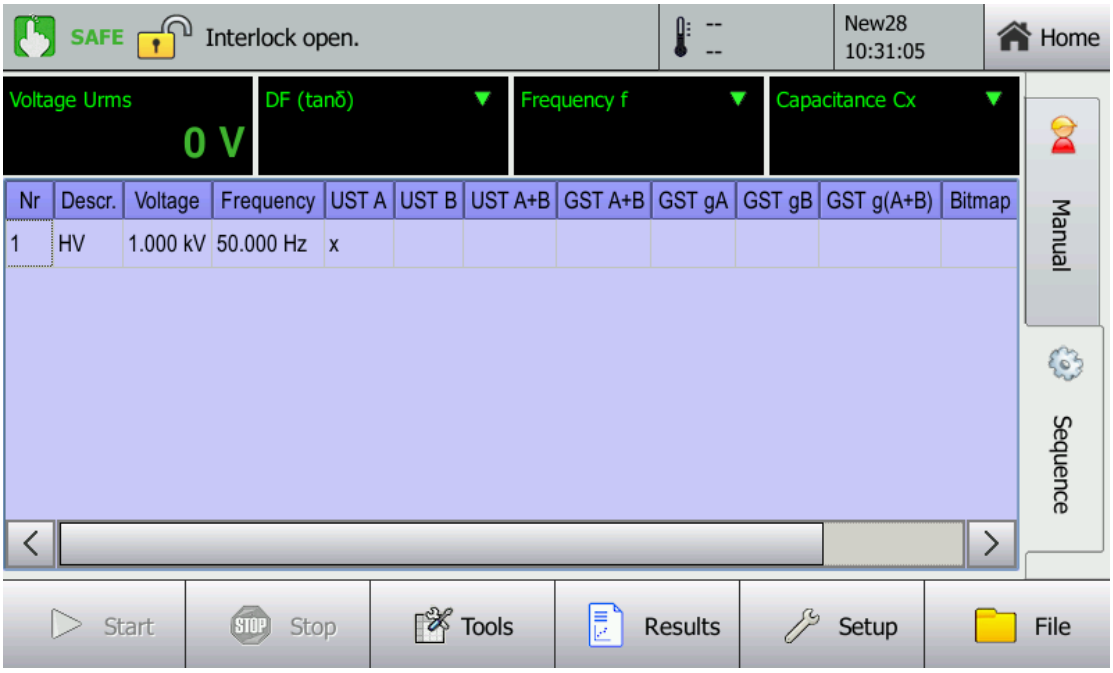


File transfer dialog

	**Copy Files to** Allows copying files from the MIDAS micro 2883 to the external USB Drive (arrow to the right) or from the USB Drive to the instrument (arrow to the left). Select files either in the file list to the left (contents of 2883 storage) or to the right (contents of USB Drive) then click on the corresponding arrow button.
	**Add Folder** Allows adding a new folder on the external USB Drive
	**Go to higher level folder** Click here to go one level up in the folder hierarchy.
	**Select File type** Allows selecting which type of file is displayed in the file lists. Measurement files (xml or csv) and Image Files (bmp) are possible selections. Images can be used in self-defined sequences. See chapter 11.2.1 Setting up a Sequence.

11.2 Sequence Tab

The sequence tab gives the user the possibility to generate personalized automated measurement sequences. All the parameters can be freely determined for every step. In addition to that images and instructions can be defined to lead through the test procedure.



11.2.1 Setting up a Sequence

The sequence can be defined in the sequence window. Each value can be edited by double clicking the corresponding cell or by marking it and the using the edit command in the tools menu.

Nr	Descr.	Voltage	Frequency	UST A	UST B	UST A+B	GST A+B	GST gA	GST gB	GST g(A+B)	Bitmap	Text
1	HV	1.000 kV	50.000 Hz	x								

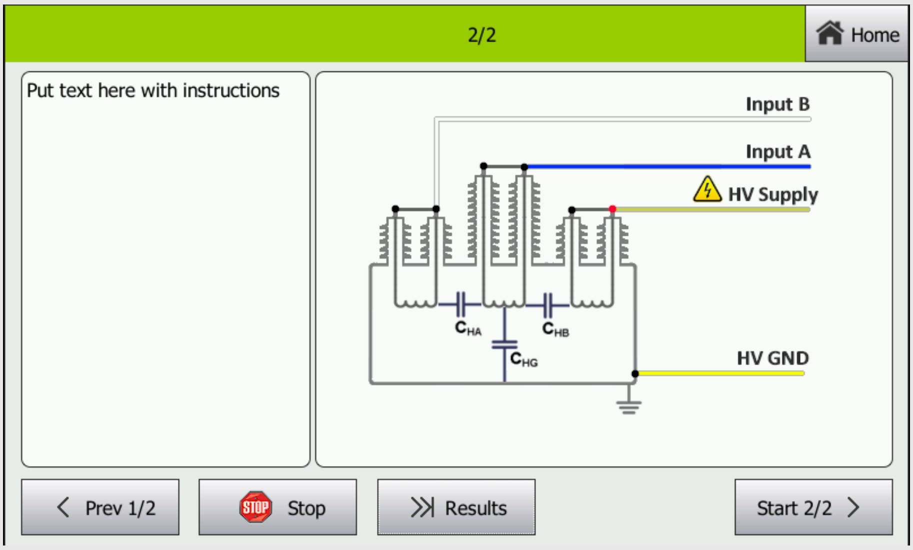
Sequence window

The table below shows the meaning of the column headers.

Field	Description
Nr	Number of line or measurement in the sequence
Descr.	Description of the Measurement to perform. This text can be used to filter the measurements in the results screen.
Voltage	The test voltage for the measurement
Frequency	Frequency for the measurement
UST A ***UST B*** ***UST A+B*** ***GST A+B*** ***GST gA*** ***GST gB*** ***GST g(A+B)***	These columns determine if a test mode is measured with the frequency and voltage given in the previous columns. If the cell is empty the test mode is not measured. If there is any text inside the cell, the test mode will be measured. This text can be a simple “x”, or the user can directly enter some more speaking description. For example the user can enter here which capacitance of a transformer is measured (e.g. CHL). These tags can also be used in the results screen to filter the measurements. If more than one connection per line is selected then the connections will be measured one after another beginning left going to the right.
Bitmap ***Text***	This column permits to define a bitmap and a text, which will be displayed at the beginning of the sequence step. If a bitmap or a text is set, then a pop-up will show up, displaying the text and the image. This can be used to give the end user instructions about the connections of the probes. Example:

Bitmap	Text
3W1Ph_MV.bmp	Put text here with instructions

Will be displayed like this:



Example for a sequence:

Nr	Descr.	Voltage	Frequency	UST A	UST B	UST A+B	GST A+B	GST gA	GST gB	GST g(A+B)
1		2 kV	50 Hz	x						
2		4 kV	50 Hz	x	x					
3		6 kV	60 Hz							x

The sequence displayed above will perform the following measurements, in the following order:

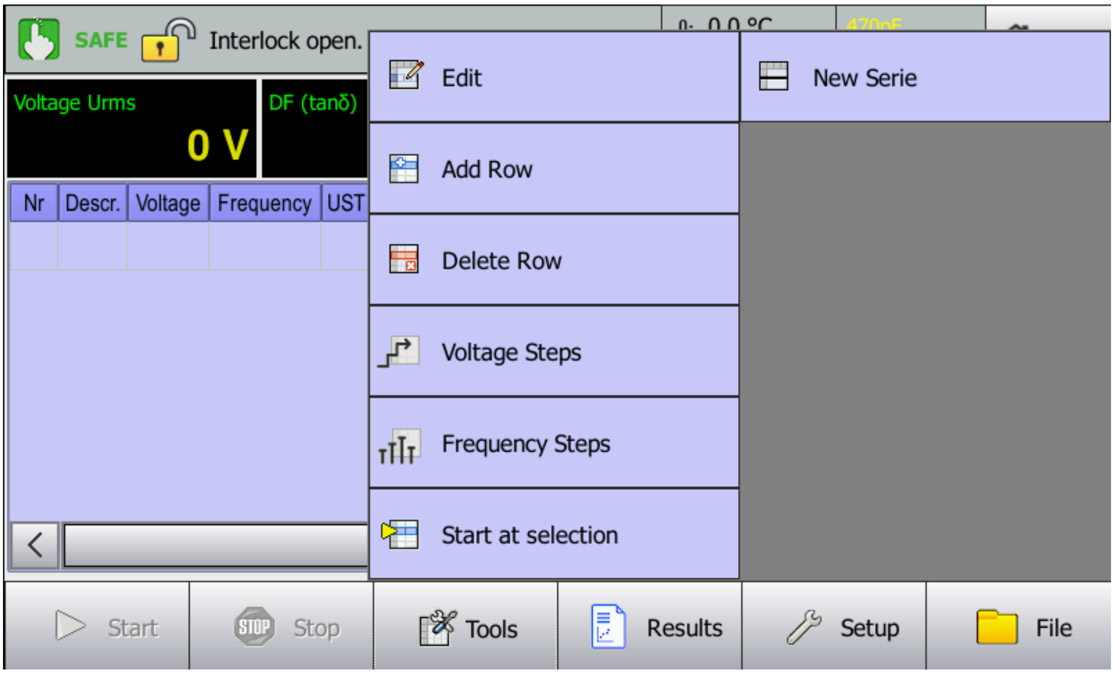
UST A @ 2kV, 50 Hz

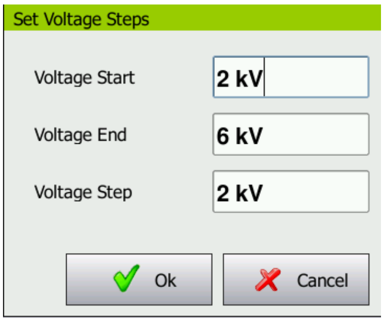
UST A @ 4kV, 50 Hz

UST B @ 4kV, 50 Hz

GST g(A+B) @ 6kV, 60Hz

11.2.2 The Tools Menu

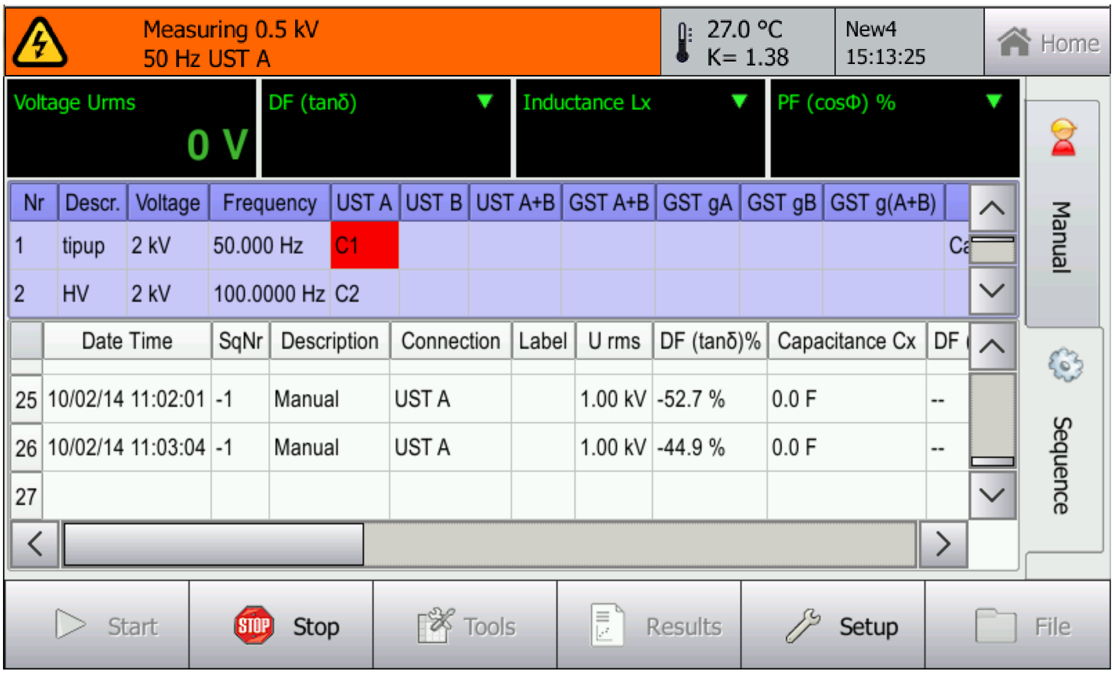


Edit	**Edit** Edits the currently selected cell.	
Add Row	**Add Row** Adds a sequence step. The new step will be inserted after the currently selected line, copying its values. The new line can afterwards be edited.	
Delete Row	**Delete Row** Deletes the currently selected row(s)	
Voltage Steps	**Voltage Steps** Define a sub sequence of voltage steps. You can create automatically multiple voltage measurement points by giving a start and an end voltage as well as a step size.	
Frequency Steps	**Frequency Steps** Define a sub sequence of voltage steps. You can create automatically multiple voltage measurement points by giving a start and an end voltage as well as a step size.	Enter a start and end voltage/frequency as well as a step size. The software generates a sequence with these parameters. In the given example the sequence steps would be: 2kV, 4kV, 6kV
Start at selection	**Start at selection** Starts the sequence at the currently selected cell in the sequence window.	
New Serie	**New Series** Inserts a blank line in order to divide the sequence into sub sequences. This blank row will also appear in the results and allows grouping together parts of the sequence.	

11.2.3 File Menu

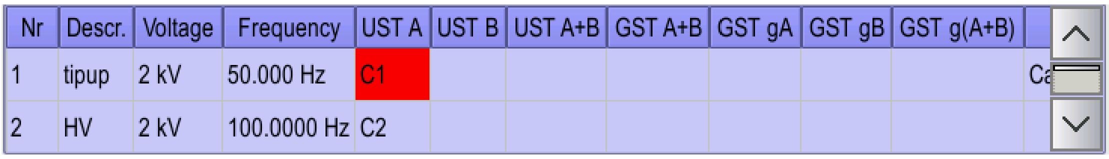
The file menu in the sequence tab is identical to the one in the manual tab, see chapter 11.1.7

11.2.4 Sequence tab during measurement

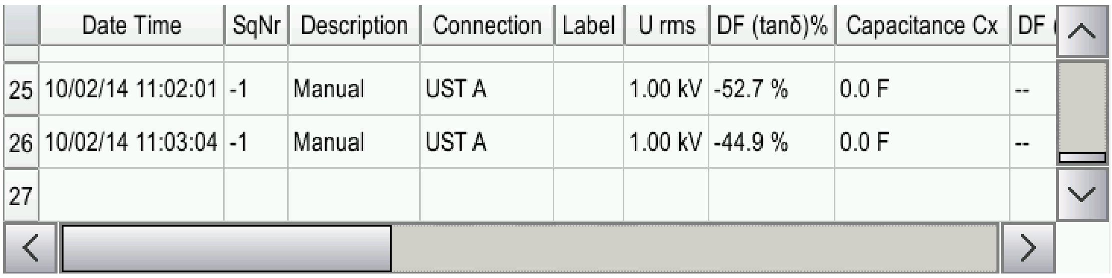


The sequence tab during measurement

During measurement the sequence display area is split into two part: in the top the actual sequence step is shown and in the bottom the measurement results. A red indicator marks the sequence step currently measured. The results will be filled into the measurement display area while the sequence is running.



The sequence area



The measured values area

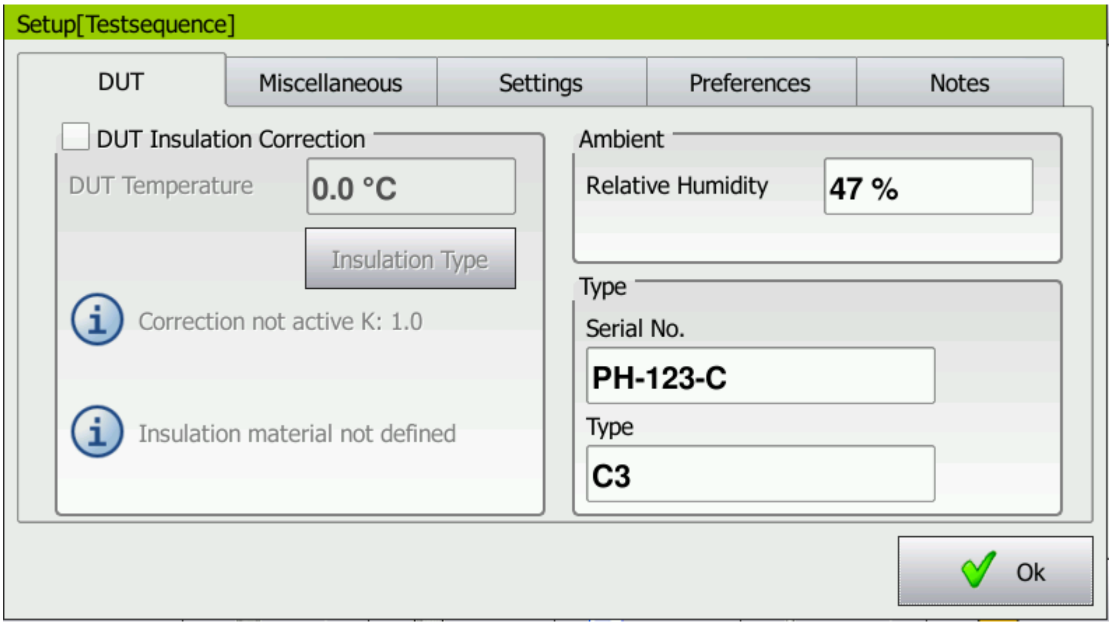
	**Stop Button** Stops the sequence and turns off the high voltage output.
	**Setup Button** Leads to the setup screen. See chapter 12 Setup.
	**Current Step** The red marker shows which measurement is currently performed.

12 Setup

The setup screen can be accessed from different modes. Dependant on that mode the setup tabs may vary.

12.1 DUT tab

Not available in: Homescreen

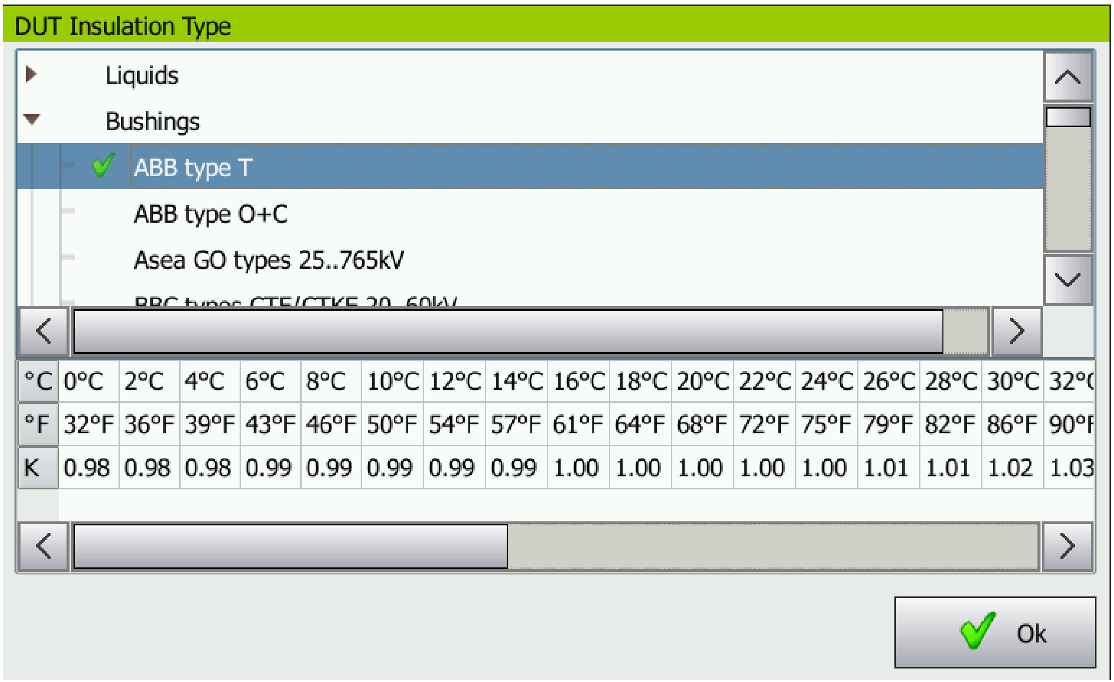


The DUT tab

On the DUT tab the user can enter information about the device under test. Under Type the serial number and the type of the device can be entered. In the Ambient box the relative humidity can be entered (for example measured with the optional hygrometer).

On the left side the DUT Insulation Correction allows the user to define the insulation type of the device under test and to correct the measured values according to this insulation type and the temperature. The DUT Temperature can be entered manually (when measured with the hygrometer) or will be measured automatically (when using the optional external temperature probe)

By clicking on the Insulation Type button the following dialog window opens up.



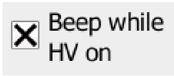
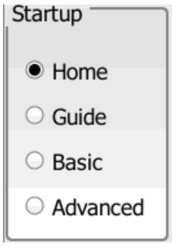
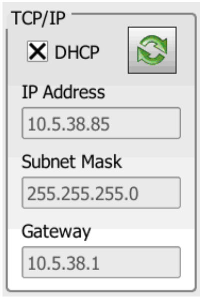
Here you can first select the type of device and the manufacturer in order to load the corresponding correction table.

When a DUT temperature correction is selected, the measurement values “@ 20°C” will be calculated automatically using the corresponding correction table.

12.2 Miscellaneous Tab

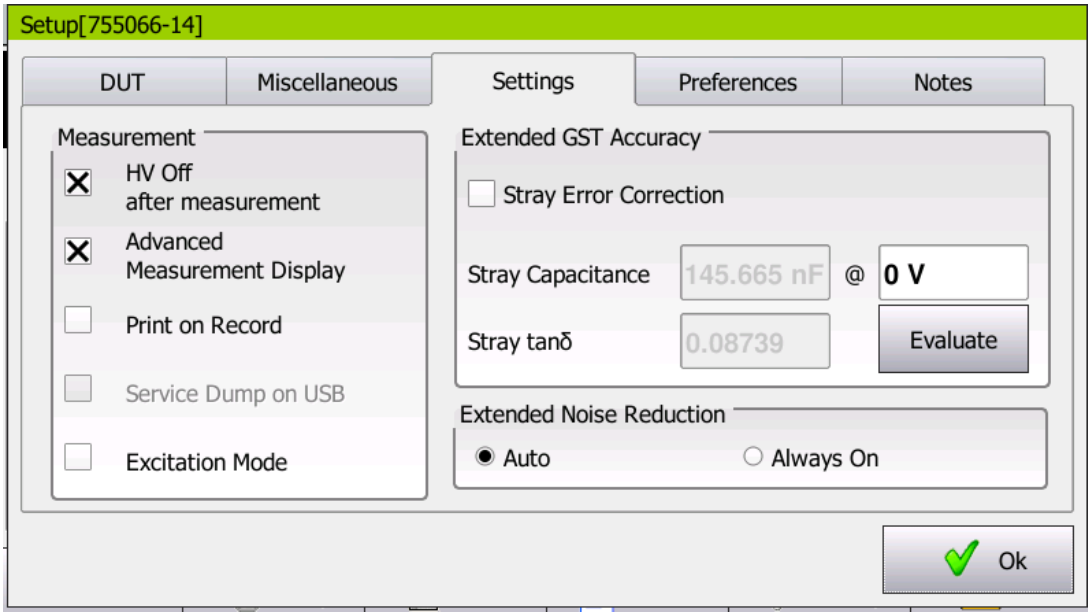
The miscellaneous tab

The miscellaneous tab provides various settings and information about the soft- and hardware. It is also the starting point for firmware updates or restoring factory default settings.

	**Sound ON/OFF** Select if a warning sound is issued whenever high voltage is turned on
	**Startup Screen Selector** Select in which mode the software starts up. If you are using always the same mode you can access it directly like this, without opening the home screen first.
	**TCP/IP settings** All the necessary settings can be done here if the device is connected to a network. When DHCP is selected, the device will get an IP address automatically from a DHCP server. The green arrows allow refreshing the DHCP lease.
	**Device Information** Provides information about the device, such as Serial Number, Soft- and Hardware versioning and Calibration. Please provide this information when contacting Tettex Support.
	**Load Factory Default** All the settings will be reset to the factory defaults.
	**Set Date & Time** Set the Date and Time of the device. Time and Date are used to timestamp the measurements.
	**Firmware Update** Switch to the Firmware Update Program. See chapter 12.7 Firmware Update.
	**Change Language** Displays the list of all available languages. Click on the language to select it.
 	**Selftest** Performs a selftest, verifying the calibration and the functionality of the safety elements. The user is guided through the test by on screen dialogs. The results of the single tests are stated “passed” or “FAILED” on the display and can also be printed out. **Remark** The test result of the (optional) external temperature sensor is logically stated “FAILED” if it’ s not connected, respectively not applicable.

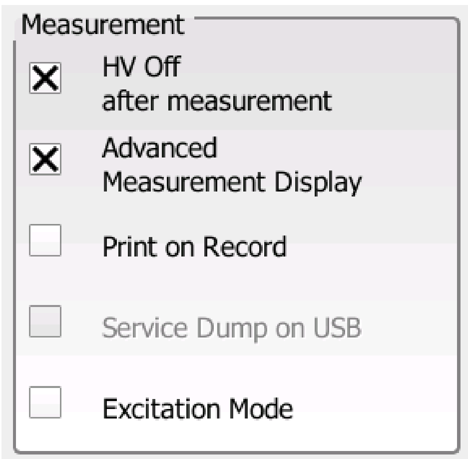
12.3 Settings Tab

Some of the measurement settings not available in Basic Mode



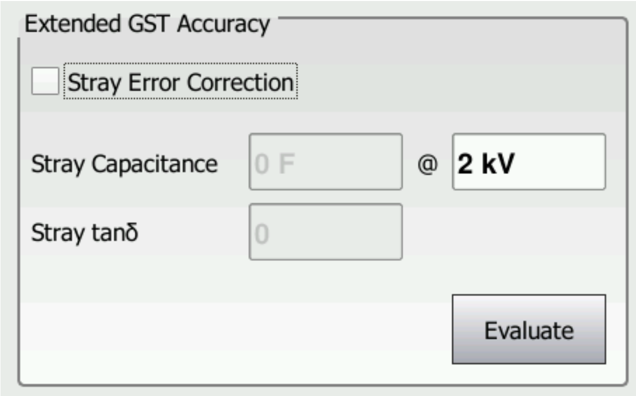
The Settings tab

12.3.1 Measurement settings

	**HV Off after measurement** Normally checked. Automatically turns off the high voltage in manual mode when a valid and stable measurement value has been recorded. Deselect if the high voltage should not be switched off after a measurement recording.
	Advanced Measurement Display Select if the advanced measurement values are selectable or if the selection is limited to the most common values. Limiting the number of measurement values makes it easier to find a specific one.
	Print on Record Prints the measurement values on-the-go, i.e. every newly recorded value is added to the printout.
	Service Dump on USB Saves real data on USB memory stick. Used for service purposes only.
	Excitation Mode Activates the special mode for excitation current measurements. In this mode the regulation and stability criteria will be based on the measured current and not on the voltage and dissipation factor. This allows to measure higher currents at low voltages and to get faster results than in normal mode. In excitation mode noise suppression isn't available. Do not use this mode for normal C/DF measurements.

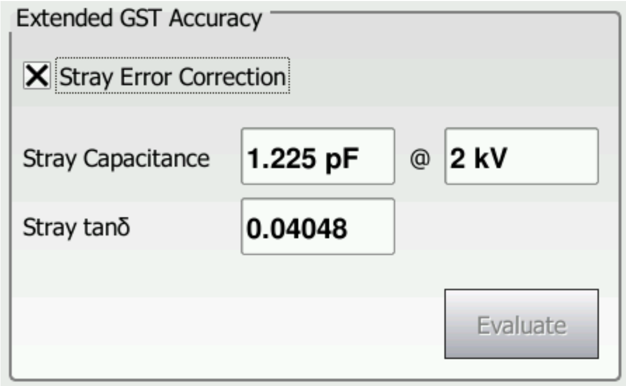
12.3.2 Extended GST accuracy

The right side of this setup tab is dedicated to the Extended GST Accuracy settings.

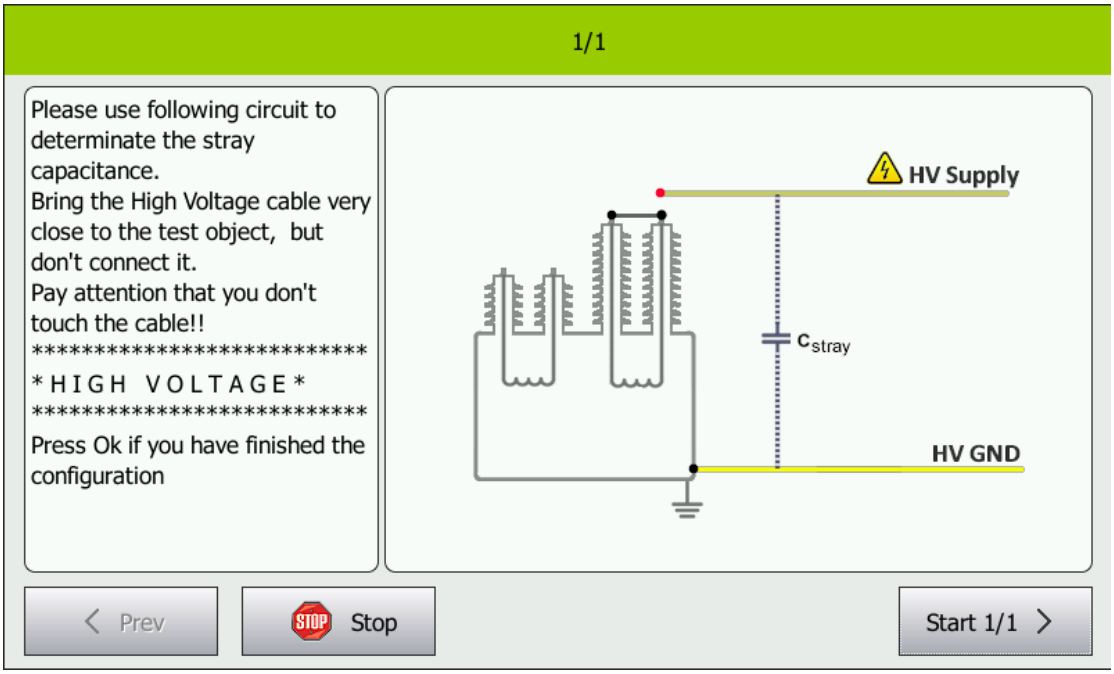


When measuring a grounded specimen all stray capacitances between high voltage and ground enter the measurement. Normally the influence of these stray capacitances is small. However, when measuring devices with small capacitance (<1nF), this may induce a considerable error to the measurement. Therefore the MIDAS micro 2883 provides the possibility to measure these stray capacitances and compensate them afterwards in the measurement of the device.

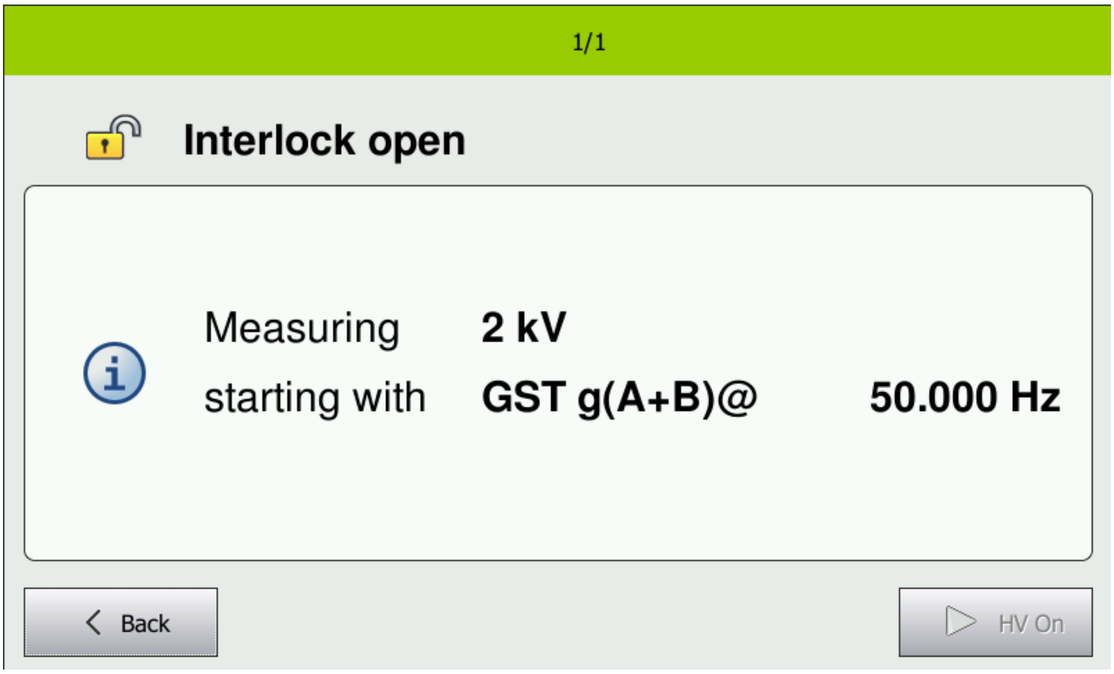
Enable the Stray Error Correction by clicking the checkbox. The values can now also be edited manually, which is only recommended for expert users. If you want to re-evaluate the Stray Capacitance you have to uncheck the stray error correction checkbox first and then click on the Evaluate Button as described above.



In order to measure the stray capacitances, disconnect the HV cable from the DUT, but leave it in a position which is as similar as possible to the position when connected. Make sure the clamp is isolated from any conducting parts. When ready press the Start Button. Press Stop to return to the setup screen.



The preparation screen informs about the current settings and the present warnings. Press HV On to start the measurement.



During the measurement the top bar is blinking red to indicate that high voltage is on. The relevant measurement values are displayed. Please wait until a stable value has been determined.

Once the measurement is complete you will be informed in a popup window which will lead back to the setup screen.

The measured values are now filled into the fields Stray Capacitance and Stray tan δ (the power factor value is also evaluated and corrected, but not specially displayed).

12.3.3 Extended Noise Reduction

Firmware Version 1.1.0 and greater

The MIDAS micro 2883 incorportates The Extended Noise Reduction

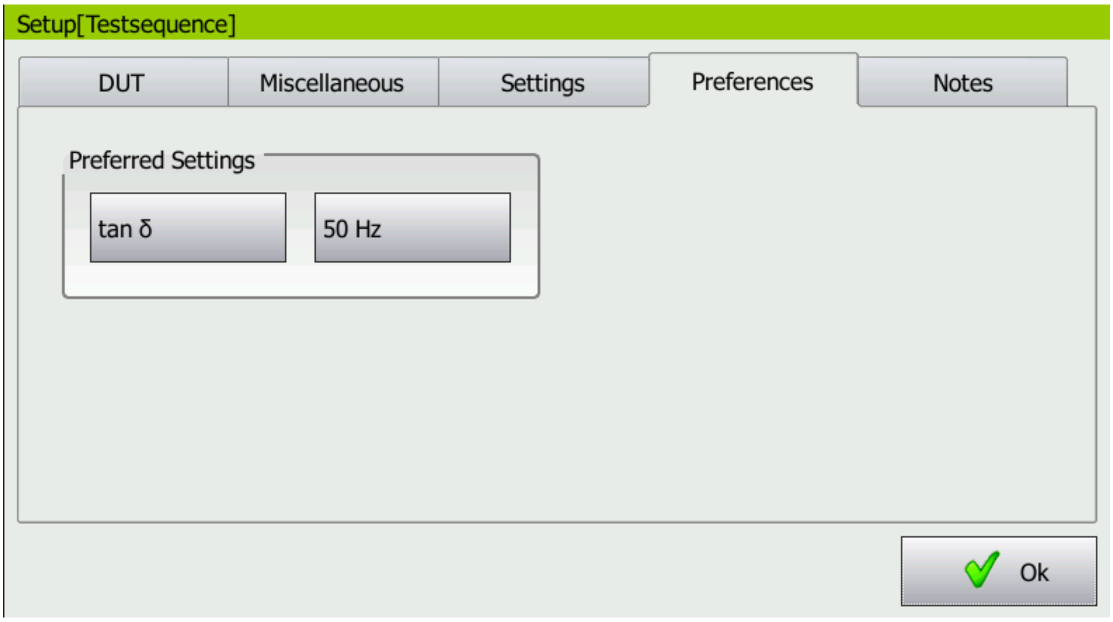
The Midas micro uses special filter algorithms to reduce the noise and extract the measuring signal. See chapter 6.4 for more information.

The extend noise reduction feature is switched on permanently if the “Always On” option is selected. This guarantees always high accuracy measurement but the measurement speed is reduced. This is the recommended selection.

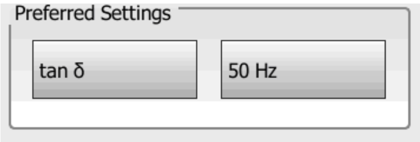
If “Auto” is selected the instrument starts automatically the right algorithm whenever a low signal to noise ratio is detected. In low noise environment this selection optimizes the speed of the measurement.

12.4 Preferences Tab

Only available on home screen and in advanced mode



The preferred settings decide which values will be displayed by default in the measurement display. Normally after setting up the unit the last set values are used again after a restart in the setup respectively in the display.

	**Select preferred values** Select between tan δ or DF and 50 or 60 Hz as standard values.

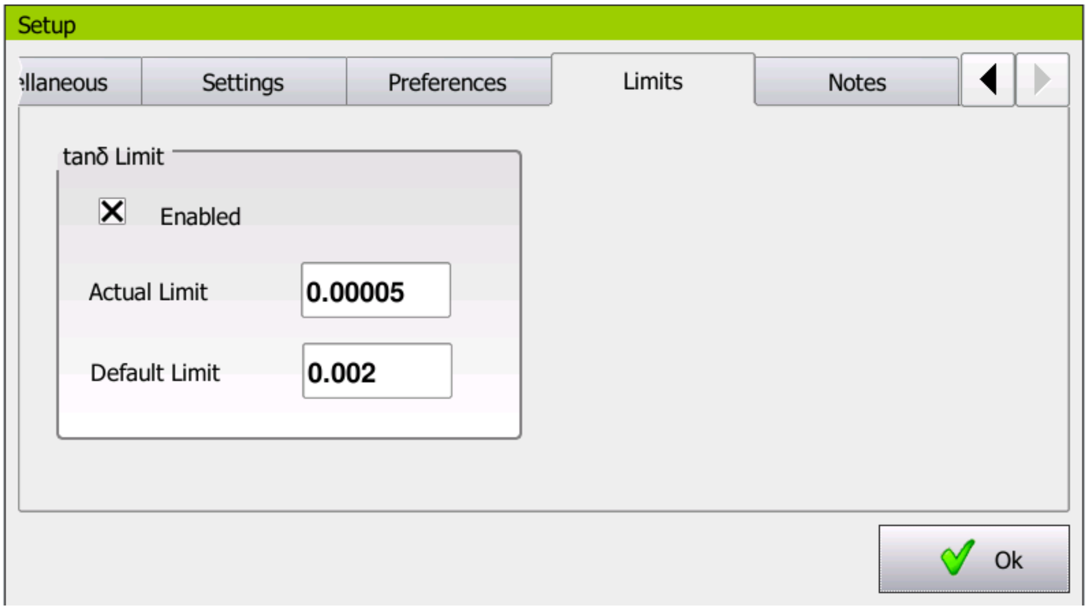
12.5 Limits Tab

It is possible to define a tan delta limit as a pass/fail flag for the test, on this screen the Actual Limit and the default Limit can be defined. If the limits are enable a pass fail flag column will be added to the results after selected

Actual limit is the value to be used on the actual test

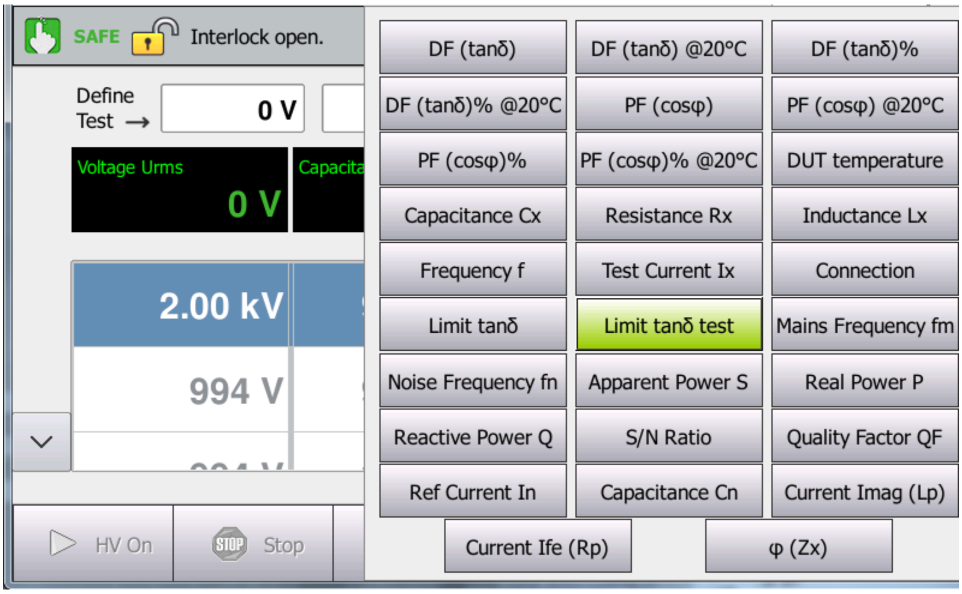
Default limit is the default limt defined when a new test is selected

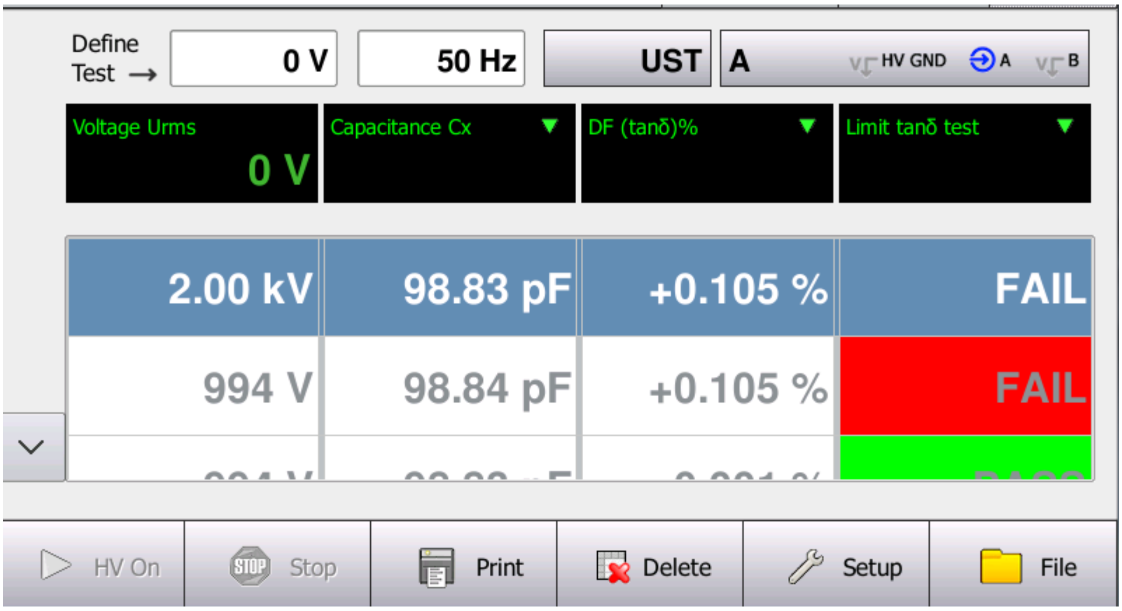
Limits are defined for a complete test, and should not be changed during the measurement.



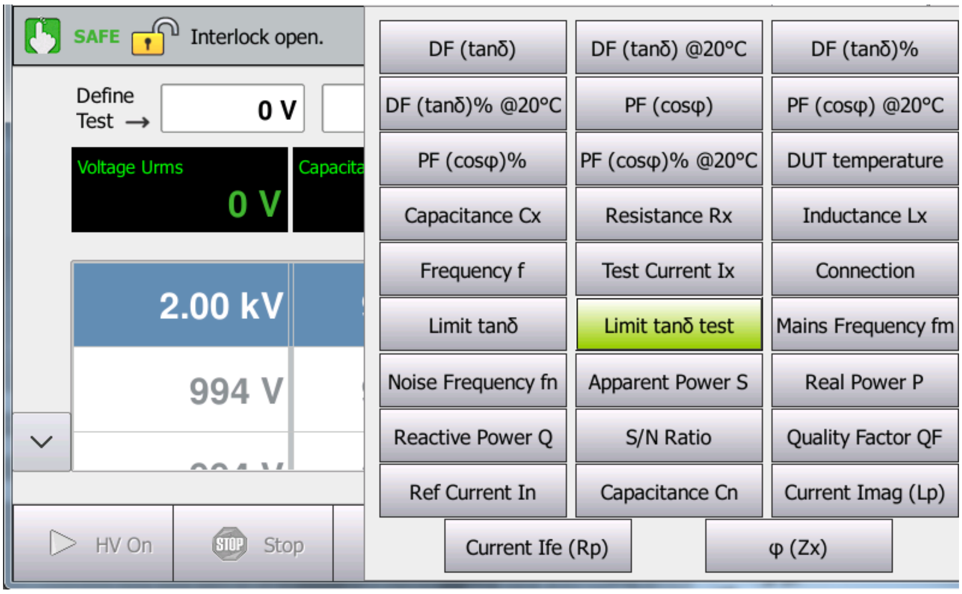
12.5.1 Limits in Basic mode

To see the pass/Fail flag, select “Limit tanδ test” in one of the indicators. Then a Green “Pass” or a red “Fail square will be shown after a measuring point is finalized in the corresponding column

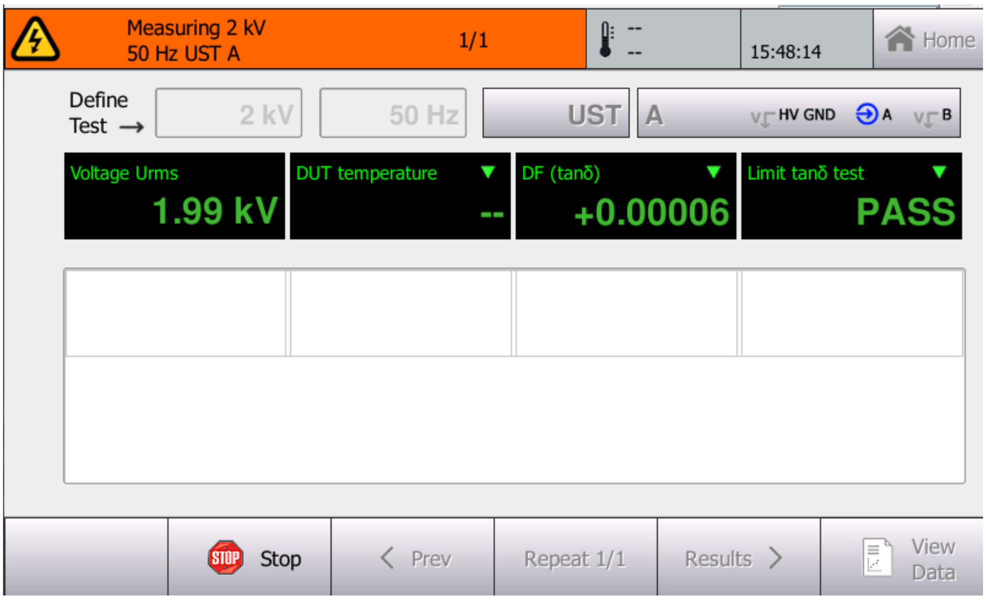




12.5.1 Limits in Guided mode



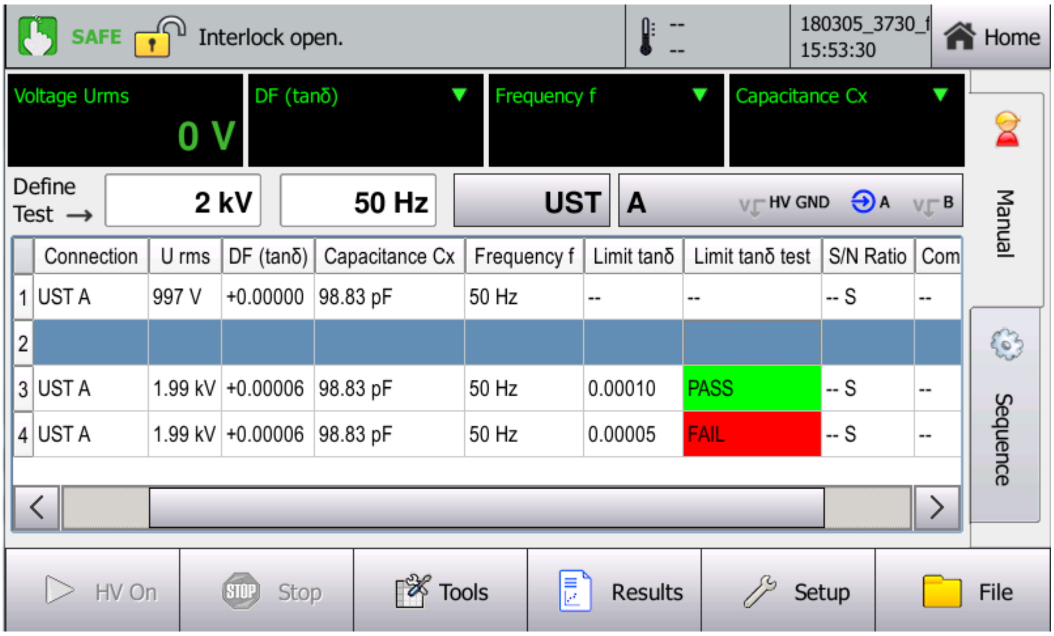
To see the pass/Fail flag, select “Limit tanδ test” in one of the indicators. Then a Green “Pass” or a red “Fail square will be shown after a measuring point is finalized in the corresponding column



12.5.1 Limits in Advance mode

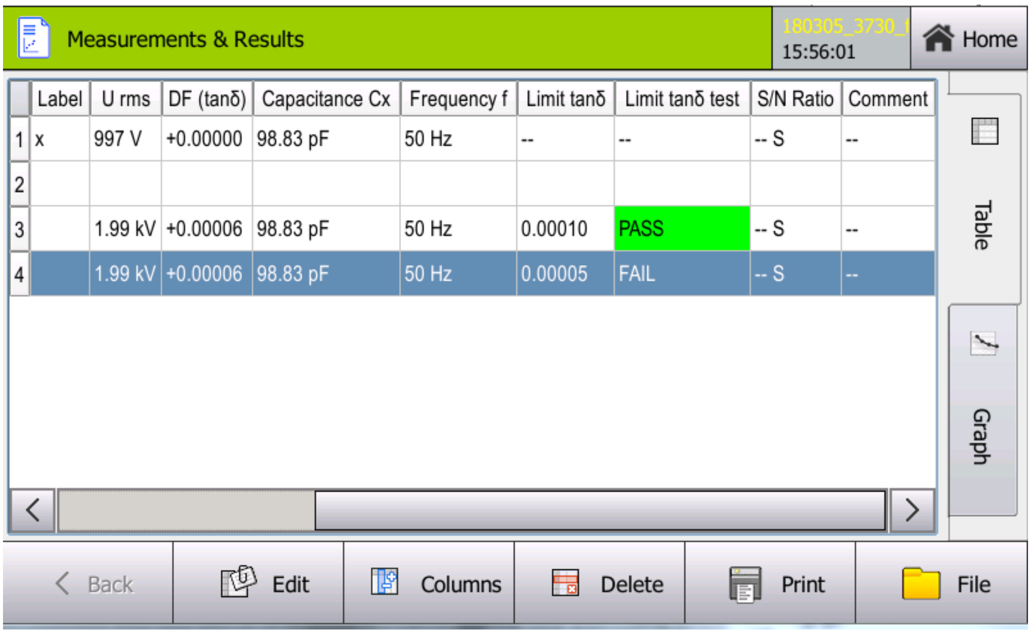
In advance mode, the limit values can be added as columns to the measurement, 2 columns can be added

- Limit tan δ -> contains the actual value used for comparison
- Limit tanδ test -> the pass/Fail Flag

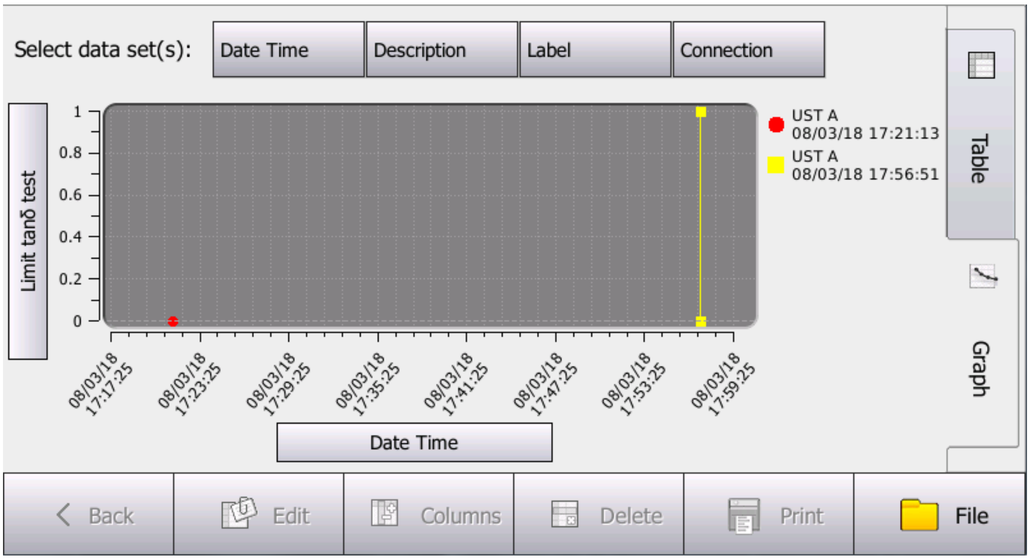


12.5.1 Limits in Reports and Graph

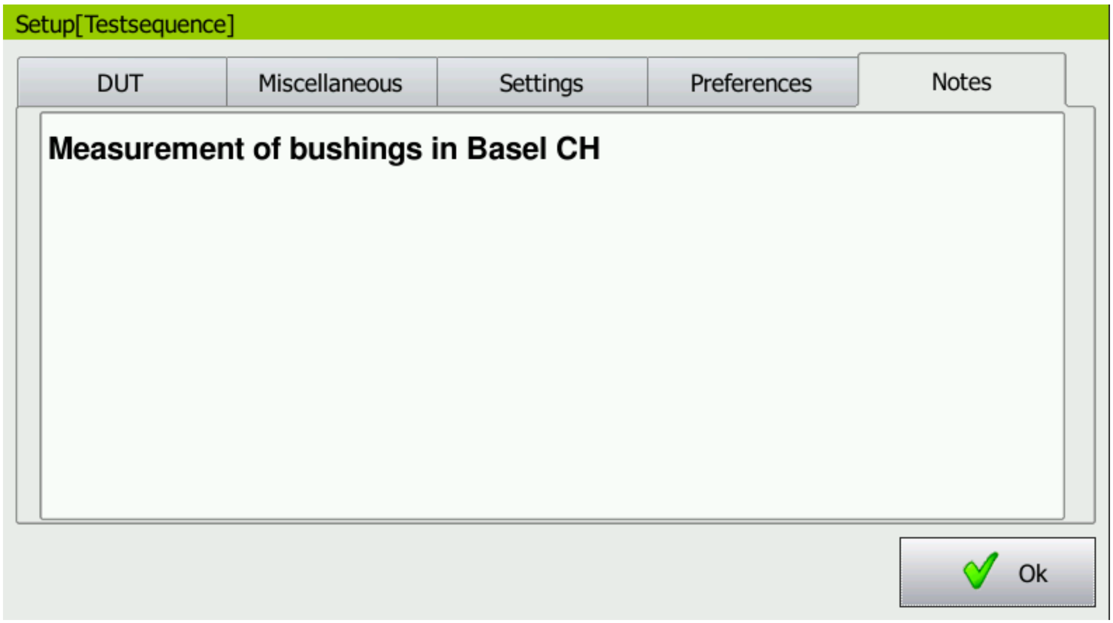
The limit used for evaluation is recorded for every measurement, and will be shown in the report and in the CSV file for each row.



The limits can also be selected for the Y axe in the Graphs, will be coded as 0 if passed, 1 in fail



12.6 Notes Tab



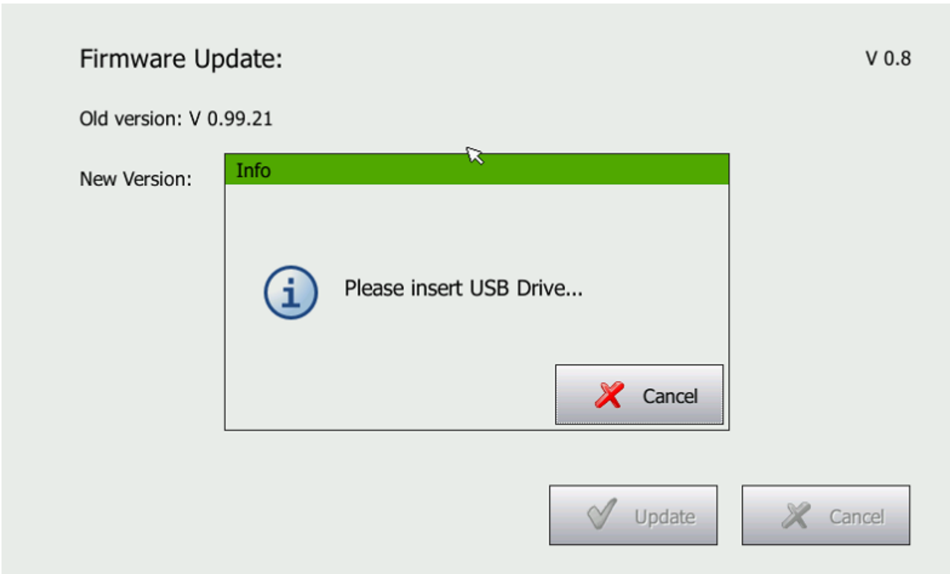
The notes tab

Use this page to make any notes you want to save inside the measurement file.

12.7 Firmware Update

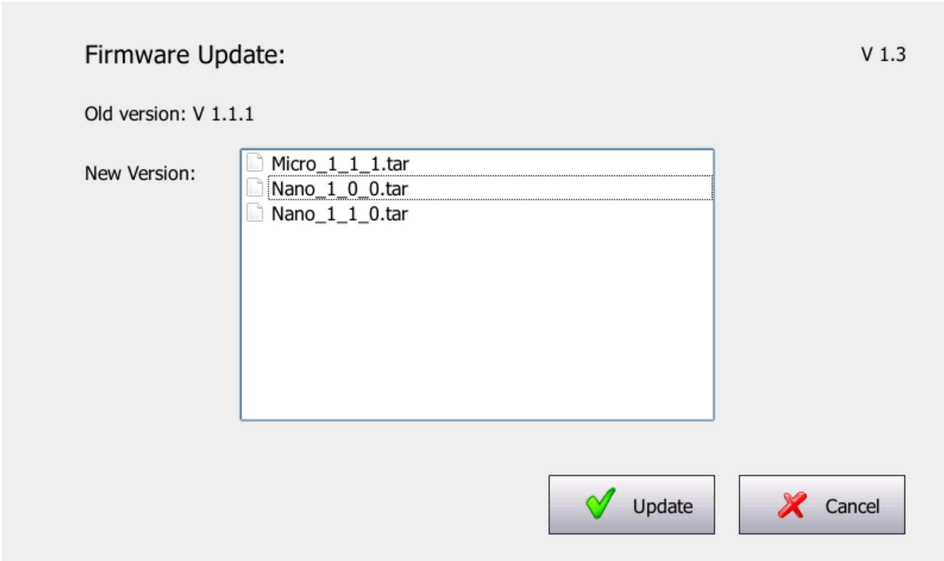
In order to provide the user with the latest features and bug fixes a firmware updater is implemented in the Midas micro software. The firmware updater can be accessed through the setup on the miscellaneous tab (see chapter 12 Setup).

When Entering the Firmware Update you will be prompted to insert a USB drive containing the update files.



Prompt to insert USB Drive

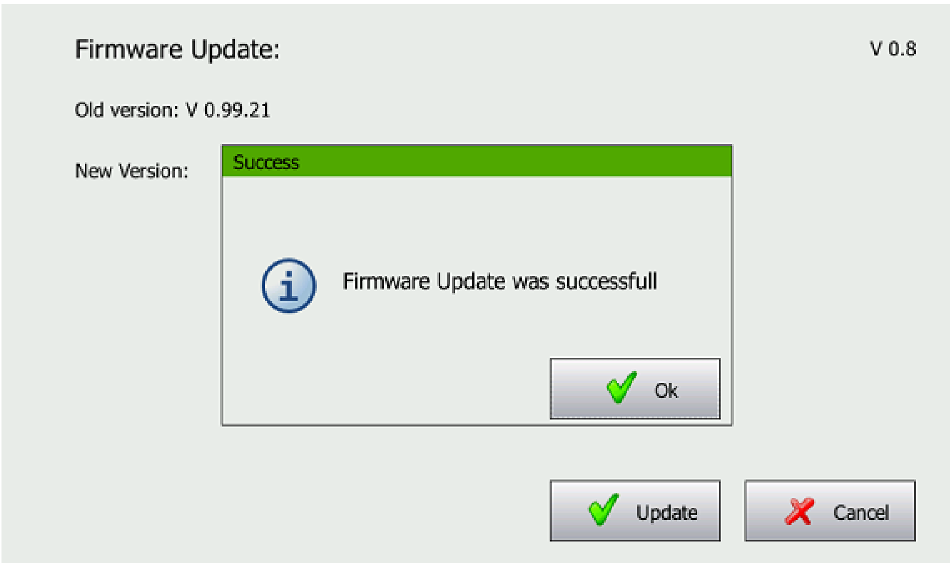
Once the USB drive is detected, the available Update Files are listed for selection.



Update File selection

The firmware file name changed from Nano_1_x_x.tar to Micro_1_1_.tar

Select the update file you want to install and click on the Update Button. Pop-up windows will inform you about the progress of the update. When finished, you will be informed of the successful completion of the update and prompted to restart the instrument.



Update successfully completed

The latest firmware is available on the Haefely update page:

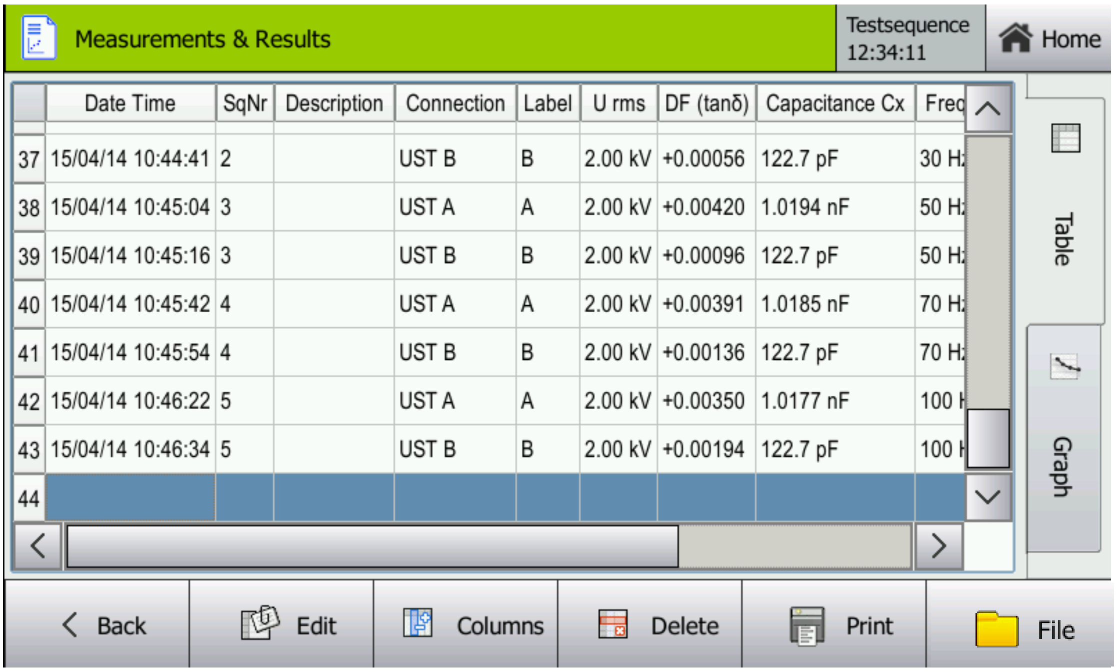
http://update.haefely.com/MIDASmicro2883/

13 Results Screen

The results screen lets you analyze the actual and previous measurements (when saved). It is composed of two tabs. The table tab shows a listing of all the results. The graph tab shows a graph of selected measurements. The results screen is a powerful tool to analyze the measurement results onsite. It allows the user to detect errors or irregularities in test setup. Detecting errors onsite or even during a measurement sequence allows to repeat the test with little effort.

13.1 The Table Tab

The table tab lists all the measured values in a table. You can select the columns of measurement values which should be displayed. Comments can be edited or measurement values deleted or printed.



The table tab of the results screen

	**Back Button** Leads back to the last screen (only available in Guided Mode)
	**Edit Button** Edits the comment for the marked line(s).
	**Select Columns Button** Allows the user to select which measurement values should be displayed. Opens a dialog window. See chapter 13.1.2 Select Columns Dialog for further instructions.
	**Delete Row Button** Deletes the selected row(s).

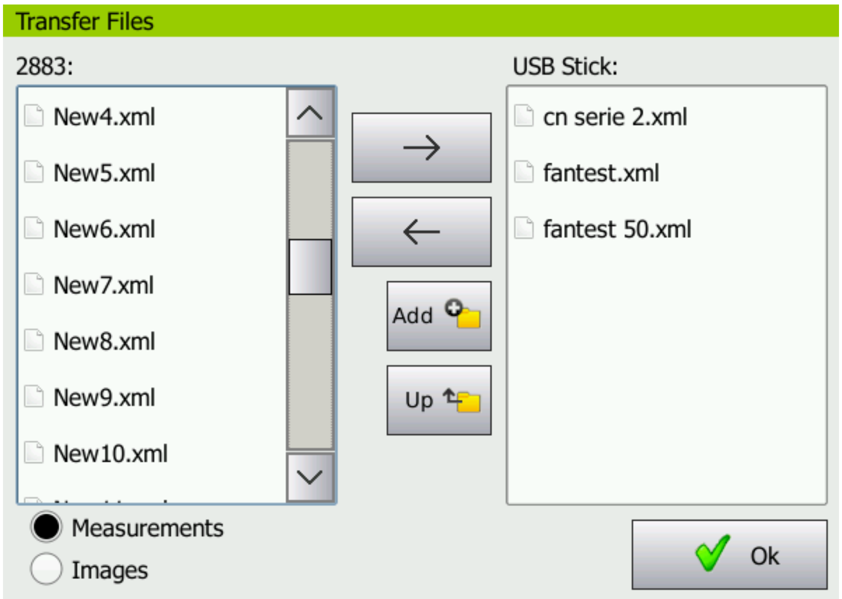
Print	**Print Button** Prints the selected row(s) on the strip printer.
File	**File Button** Opens the File Menu

13.1.1 The File Menu

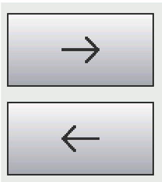
The internal file system of the Midas micro 2883 is an XML structure. If a measuring data transfer to the USB stick is performed the data are always exported in two formats: XML and CSV.
Due to clarity reasons only the XML files are visualized in the file list structures to keep the interface simple.

New	**New File** Creates a new, empty file.
Load	**Load File** Loads an existing file from the internal storage.
Save	**Save File** Saves the current file on the internal storage.
Save As	**Save File As** Saves the current file under a new name.
Delete	**Delete File** Allows deleting any measurement file on the internal storage.
USB Transfer	**USB Transfer** Allows transferring files from or to an external USB Drive. Opens up a transfer dialog window.

USB Transfer

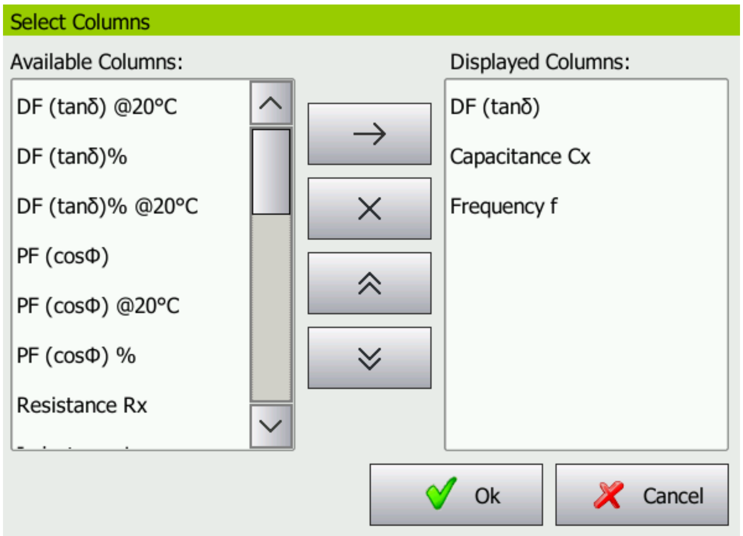


File transfer dialog

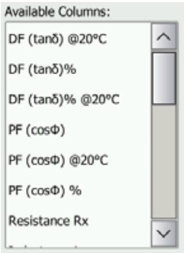
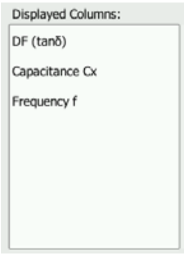
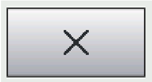
	**Copy Files to** Allows copying files from the MIDAS micro 2883 to the external USB Drive (arrow to the right) or from the USB Drive to the instrument (arrow to the left). Select files either in the file list to the left (contents of 2883 storage) or to the right (contents of USB Drive) then click on the corresponding arrow button.
	**Add Folder** Allows adding a new folder on the external USB Drive
	**Go to higher level folder** Click here to go one level up in the folder hierarchy.
	**Select File type** Allows selecting which type of file is displayed in the file lists. Measurement files (xml or csv) and Image Files (bmp) are possible selections. Images can be used in self-defined sequences. See chapter 11.2.1 Setting up a Sequence.

13.1.2 Select Columns Dialog

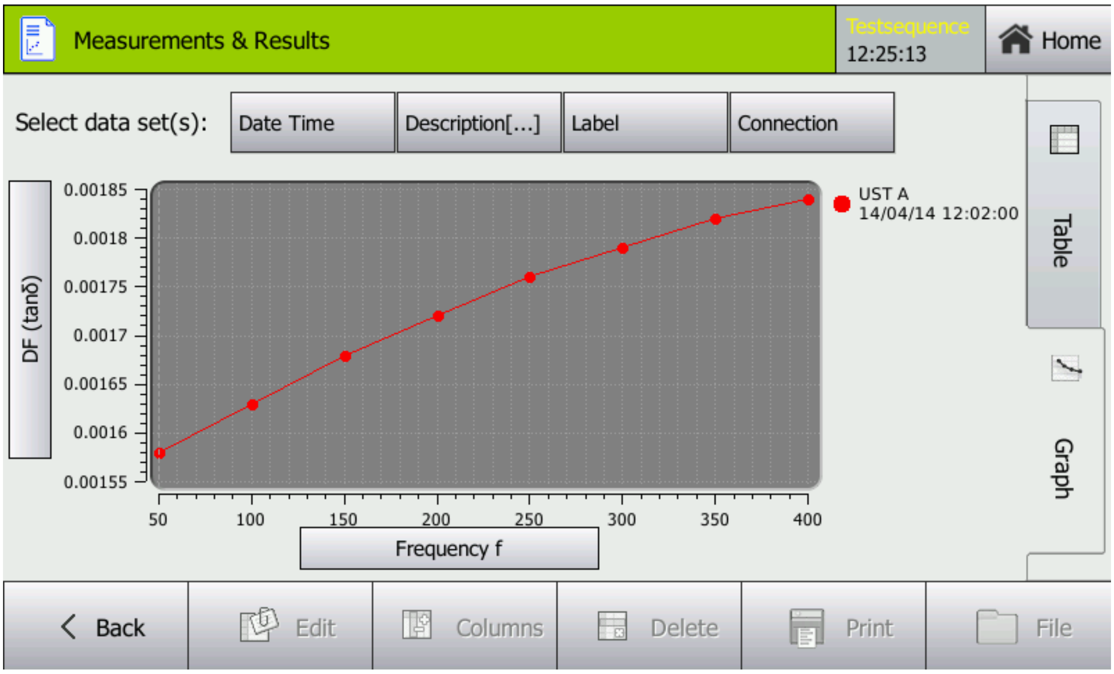
The select columns dialog allows the user to select which measurement values will be displayed.



The select columns dialog

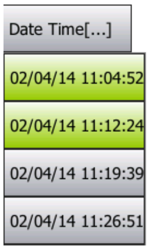
	**Available Columns** Lists all the available measurement values. You can select values by clicking on the text. For an explanation of each measurement value see chapter 14 Measurement Values.
	**Displayed Columns** Lists the measurement values which are displayed in the measurement display area. The higher an element is in the list, the more to the left it will be displayed.
	**Add Measurement category** Add the selected columns form the available columns to the displayed columns.
	**Remove Measurement category** Remove the selected columns from the displayed columns.
	**Change order** By using the arrows a measurement value can be moved up and down in the list. The higher a value is in the list, the more to the left it will be displayed in the measurement display window.

13.2 The Graph Tab

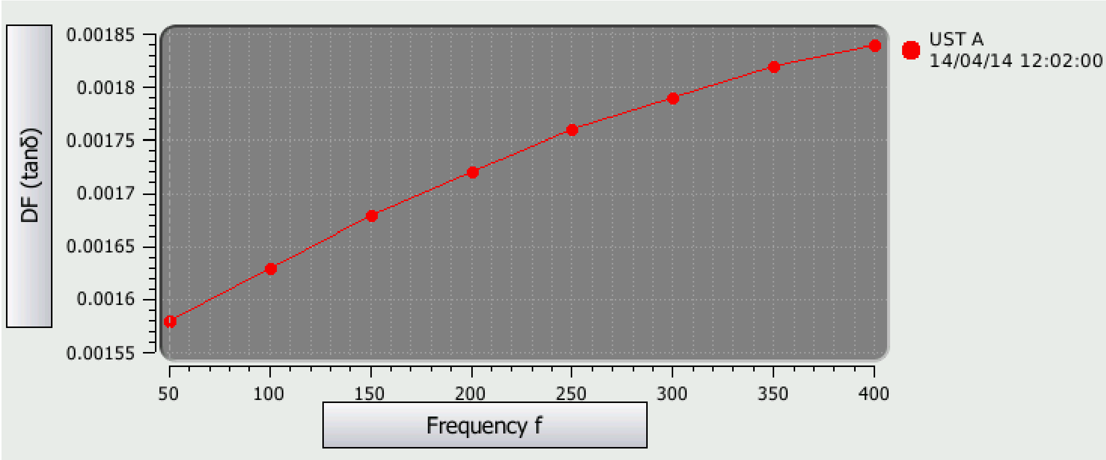


13.2.1 Filters

With the following buttons you can filter the displayed values. When clicking on one of the filter buttons a list of available filter values will open up. You can select and deselect a filter by clicking on it. The selected filters will be displayed in green.

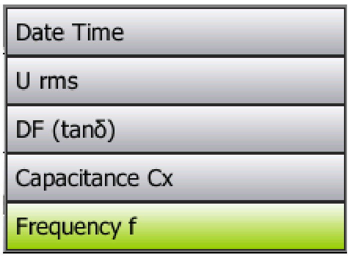
Date Time	**Date and Time** Each measurement or group of measurements (in case of a sequence) gets a timestamp. By selecting a certain timestamp you select the measurement values recorded at that time or all the values recorded in the sequence initiated at that moment. In the example on the right side the two measurement series started at 11:04 and 11:12 are selected and displayed. 
Description[...]	**Description** Lets you filter the measurement values by the description parameter. In guided mode these descriptions are predefined and express what type of measurement has been performed. In advanced mode, the selection is corresponding to the values entered in the description column of the sequence definition.
Label	**Label** The label is the description for each measured test mode. In Guided Mode this label describes which capacitance of the DUT is measured. (e.g. CHL → Capacitance between high voltage side and low voltage side). In Advanced Mode the selection will correspond to the values entered in the connection columns.
Connection	**Connection** The connection lets you select values recorded with a certain test mode. Options are UST A, B, A+B, GST A+B, gA, gB, g(A+B). Only test modes with at least one measured value will be listed.

13.2.2 The Graph



The graph area with the y axis selector on the left side, the x axis selector at the bottom and the legend at the right side.

The button on the left indicates the content of the y axis (here DF), the button on the bottom indicates the content of the x axis (here Frequency). Pressing one of these buttons will open a list of available measurement values.

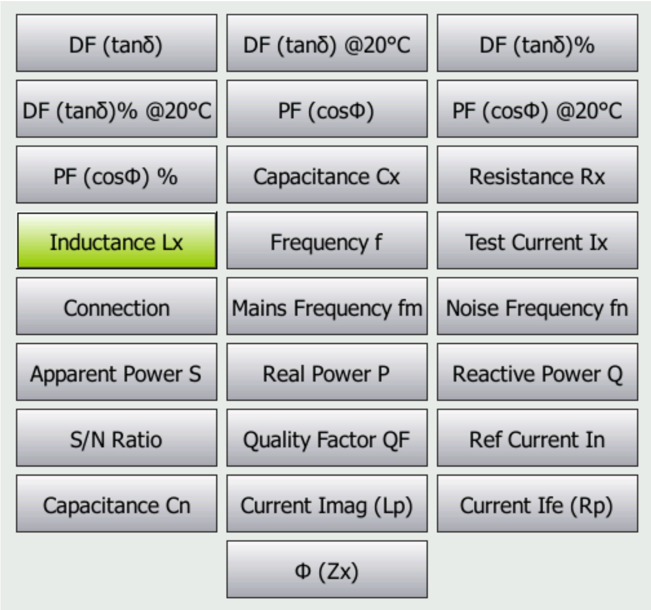


The values available for selection correspond to the selected columns in the Table tab. If you want to display a value which is not listed you have to switch to the Table tab and use the Select Columns menu to change selection.

The Legend on the right side shows which colour is assigned to which measurement.

14 Measurement Values

14.1 Description



The measurement values as they can be selected in the Midas micro software

Measurement Value	Description
DF (tan delta)	The dissipation factor or tan delta of the DUT
DF (tan delta) @ 20°C	The dissipation factor or tan delta of the DUT with temperature correction
DF (tan delta) %	The dissipation factor or tan delta of the DUT in percentage notation for better readability.
DF (tan delta) % @ 20°C	The dissipation factor or tan delta of the DUT with temperature correction in percentage notation for better readability.
PF (cos phi)	Power factor of the DUT
PF (cos phi) @ 20°C	Power factor of the DUT with temperature compensation
PF (cos phi) %	Power factor of the DUT in percentage notation for better readability.
Capacitance Cx	Capacitance of the DUT
Resistance Rx	Resistance of the DUT
Inductance Lx	Inductance of the DUT
Frequency f	Frequency of the test voltage
Test current Ix	Current flowing through the Rx Shunt resistor and therefore also through the DUT.
Connection	Connection which is currently set. (UST A, B, A+B, GST A+B, gA, gB, g(A+B))
Mains frequency fm	Frequency of the mains power.
Noise frequency fn	Frequency of interfering noise.
Apparent Power S	Apparent power dissipated at the DUT
Real Power P	Real Power dissipated at the DUT

Reactive Power Q	Reactive Power dissipated at the DUT
S/N Ratio	Signal to Noise ratio
Quality factor QF	Quality factor of the DUT (reciprocal of dissipation factor)
Ref Current In	Current flowing through the built-in standard capacitor and the Shunt Rn
Capacitance Cn	Capacitance of the internal precision Capacitor. This value is a constant which is set during device calibration.
Current Imag (Lp)	Magnetization Current
Current Ife (Rp)	Iron Loss Current
ϴ(Zx)	Phase-angle phi of the complex Impedance of the test object

14.2 Data Format

The internal file system of the Midas micro is a XML structure.

If a measuring data transfer to the USB stick is performed (see chapter 13 Results Screen) all data are always in two formats: XML and CSV.

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.

Data Example

A test named “Example“ is performed and saved in the unit. Over “Results/File/USB Transfer” the saved data are selected to be transferred to the USB stick.

Following files are transferred to the stick:

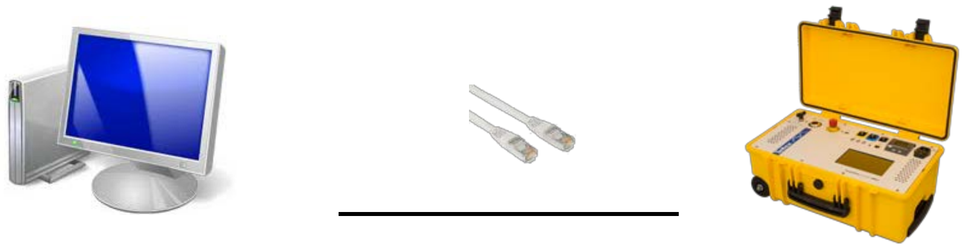
Example.csv	The CSV file, containing header and all saved data sets.
Example.xml	The XML file, containing all saved data sets in XML structure
HTAGDoc.xsl	The template information of the XML appearance of printing and showing are stored in this file. This template file is located in the root directory. For example if you want to copy the XML files anywhere on drive D, you should copy HTAGDoc.xsl to D:\HTAGDoc.xsl.
Company.jpg	The logo used in the printout. This file is located in the root directory. Initially the Tettex Logo is stored here and will be used by default. This jpg. file can be replaced by your own one – just exchange the file.

14.3 Accessing the measurement results from computer

Only available from firmware version 1.7. For firmware update see the corresponding chapter “Firmware Update”

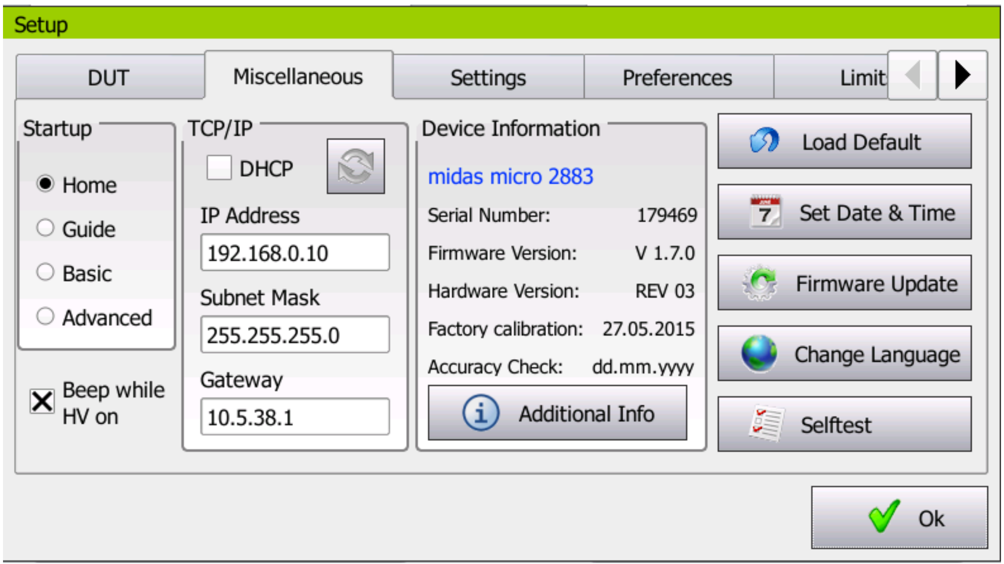
To access the measurement files inside the midas micro without using a memory stick, a ftp server is embedded into the midas micro.

To acces the measuring files, an Ethernet cable must be connected between the computer and the corresponding port in the Midas micro front panel, and and Ethernet connection must be stablished.



Address:	192.168.0.XX	Address: 10.0.0.105	Address:	192.168.0.XX	Address: 10.0.0.105
Subnet:	255.255.255.0		Subnet:	255.255.255.0	
TCP-Port:			TCP-Port:		

You can find the IP address configuration of your device in the “Setup” – “Miscellaneous” dialog:



For connection, the following configuration in the Midas micro has to be defined

DHCP -> unselected

IP Address -> 192.168.0.XXX (XXX is any number between 1 and 255)

Subnet Mask -> 255.255.255.0

In the computer, the Ethernet configuration has also to be defined as following

IP Adress -> 192.168.0.XXX (XXX is any number between 1 and 255, but diferent from the one in the midas micro)

Subnet Mask -> 255.255.255.0

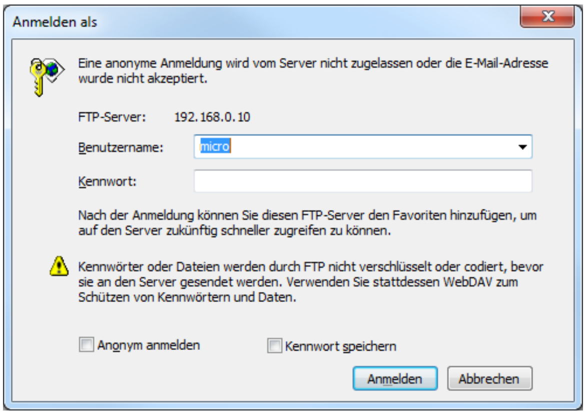
If communication is correctly setup, the answer to the “ping” command to the midas micro address has to be positive.

```
C:\>ping 192.168.0.10

Ping wird ausgeführt für 192.168.0.10 mit 32 Bytes Daten:
Antwort von 192.168.0.10: Bytes=32 Zeit=1ms TTL=64
Antwort von 192.168.0.10: Bytes=32 Zeit<1ms TTL=64
Antwort von 192.168.0.10: Bytes=32 Zeit<1ms TTL=64
Antwort von 192.168.0.10: Bytes=32 Zeit<1ms TTL=64

Ping-Statistik für 192.168.0.10:
    Pakete: Gesendet = 4, Empfangen = 4, Verloren = 0
    (0% Verlust),
Ca. Zeitangaben in Millisek.:
    Minimum = 0ms, Maximum = 1ms, Mittelwert = 0ms
```

To connect to the midas micro FTP server, open a File Explorer window in Windows and type the following command

ftp://192.168.0.XXX/ where XXX is the midas micro last part ip address

A window asking for user and password will arise

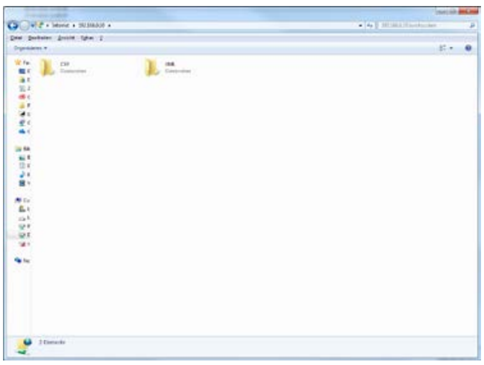


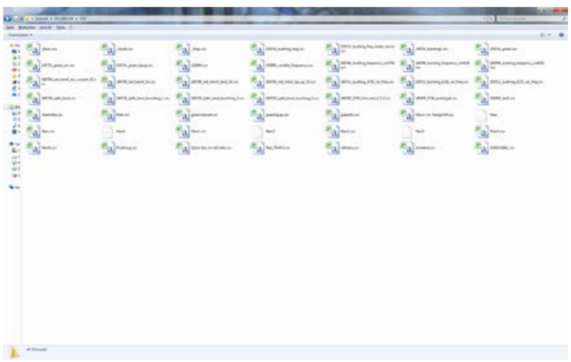
Introduce below user and password

User -> micro

Password -> micro

Then, 2 folders containing the CSV and the XML measuring files should open on the screen





The files or folders can then be copied in the local computer for modification or reporting.

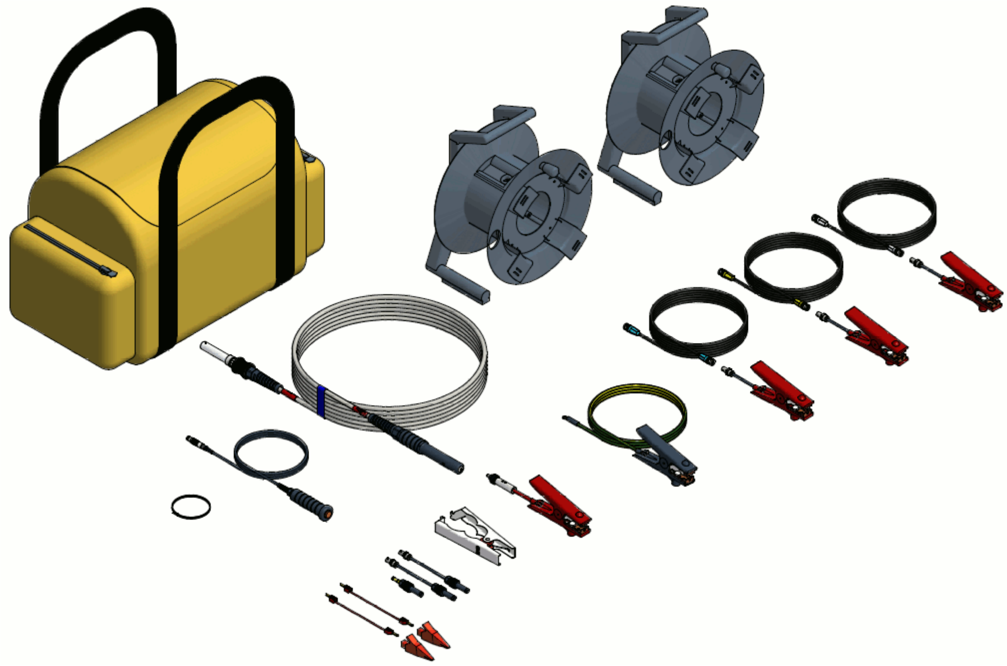
To avoid midas micro data corruption, files can not be modified inside the above folders

To avoid going trough the complete process every time, a shortcut to the CSV and XML folders can be stablised in the computer desktop by right click in the CSV or XML folder and shortcut to desktop

15 Accessories and Options

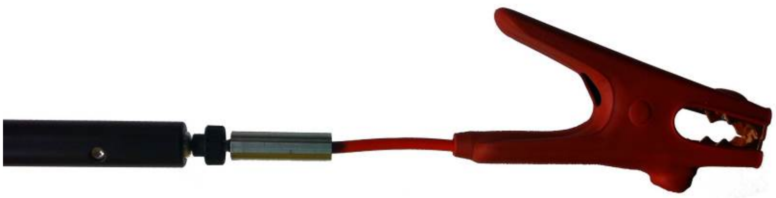
15.1 Standard Accessories

The MIDAS micro 2883 standard scope of supply includes a variety of accessories to perform various measurements. Optional accessories are also available.



15.1.1 High Voltage Cable

There are two options of connectors that can be used for the high voltage cable. Included in the standard scope of supply is a clamp and as an option a hook is available. Both can be connected by screwing the knurled head screw to the thread end of the high voltage cable.



High voltage cable with clamp

High voltage cable with hook

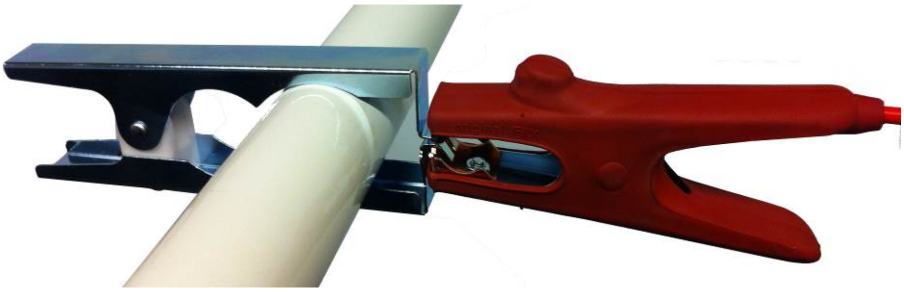
The end of the high voltage cable is non insulated parts, including the black plastic and the bare metallic part of the clamp. Make sure that these parts are placed in safe distance from any ground potential (i.e. transformer tank or bushing flange). A flashover might occur.

15.1.2 Extension clamp

A pair of extension clamps (part number 4842106) is delivered in the standard scope of supply. These can be used if the diameter of the bushing is too big for the normal (red) measuring clamps.

	Bushing diameter
Red Measurement Clamp	< 42 mm (1.6 in)
Extension Clamp, inner part	< 50 mm (2 in)
Extension Clamp, outer part	< 70 mm (2.8 in)

First connect the extension clamp to the bushing. Then connect the normal clamp on the other end.



Connecting to bigger diameters using the extension clamp with the outer part.

15.1.3 Bushing Adapters for Measurement of C1

Connecting to a bushing tap using the adapter cable.

The standard scope of supply includes two adapter cables (part number 4843453). They can be used to connect to bushings with a 4 mm test tap (i.e. Micafil type). Measured is the C1 of the bushing, see chapter 20.1 Bushings for more details.

The adapter cable is connected on one side to the bushing test tap and on the other side to the BNC connector of the measurement cable.

Only use these adapter cables together with the measurement cables for C1 measurements.

Do not use them for C2 measurements with High Voltage.

15.1.4 Bushing Adapter for Measurement of C2

a) Connecting to a bushing test tap using an additional 3 mm cable.

b) Connecting to a bushing test tap using the high voltage clamp.

The standard scope of supply includes one bushing tap adapter (part number 4843485) for measuring the C2 of bushings. See chapter 20.1 Bushings for more details about C2 measurements.

The tap adapter is connected to the 4 mm test tap of the bushing. High voltage is connected to the other end (metallic part). Either use the standard 3 mm cable (part number 0781769) or the high voltage clamp.

The voltage should be limited to the maximum voltage of the bushing test tap.

The maximum voltage of the bushing adapter is limited to 2 kV.

The metallic part of the test adapter is on high voltage potential. Make sure that the cables carrying high voltage are isolated from any part on ground potential (i.e. transformer tank).

15.1.5 Interlock adapter

The interlock adapter (part number 0781631) is used if the MIDAS micro 2883 will be integrated in an interlock system (i.e. in a high voltage laboratory). See chapter 7.1.9 Safety Switch Input for information about the pinout.

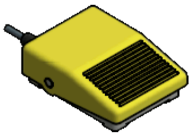
15.1.6 Cable drums

The measurement cables and high voltage cables are rolled up on cable drums. The following hints help to avoid mix up of the cables:

- Unreel the three measuring cables always together and for the same length
- Attached the loose ends of the measuring cables and the high voltage cable to the cable drum.
- There is a break that can be released for unreel and tighten for securing the cable drum.

15.2 Optional Accessories

15.2.1 Foot Switch



Product number 2883/FS

The external foot switch can be used to replace the handheld. It is therefore used to clear HV Power on. Useful if the button has to be pressed for a longer period or if the user needs his hands free.

15.2.2 Safety Strobe Light

Product number 2883/SAFE

With an external safety strobe light (optional warning lamp) it is possible to position a second high voltage indicator where all involved personnel can see it immediately (e.g. on top of the transformer tank). The function (no light, illuminated, blinking) is the same as the built-in red warning lamp.

The lamp socket is magnetic and can be mounted on each steel surface.

15.2.3 External Temperature Probe

Product number 288x TEMP

The external temperature probe is used to determine the temperature of the DUT. It is provided with a strong magnet which allows attaching it to the transformer tank or similar. Temperature measurement is then considered in temperature correction calculation.

15.2.4 Thermo-Hygrometer

Product number 288x TEMP2

The Thermo- /Hygrometer can be used to determine the ambient temperature and humidity. These values can then be entered in the DUT setup in order to calculate the temperature compensation

15.2.5 Adapter LEMO to BNC

Product number 2883/ALB

Adapter cable for standard capacitors (Lemo3 – BNC). Can be used with Tettex type capacitors having LEMO sockets. i.e.: 3370 NK

15.2.6 Hook for HV Cable

Product number 2883/HOOK

Hook for high voltage connection. Can be used instead of the clamp included in the Midas micro 2883 accessory bag.

15.2.7 Set of Hot Collar Tests

Product number 2883/HCB

Set of flexible bands for hot collar tests (see Subchapter Hot Collar Test in Chapter 20.1.2 Installed Bushings) or for guarding of leakage currents (see chapter 6.2 V-potential point and Guarding for more details).

15.2.8 Midas Office software

Product number MIDAS Office

Software for offline analysis of measurement data and creation of customized test sequences. Compatible with Windows XP, 7 and 8.

15.2.9 Oil Test Cell 6835

Test cell for on-site measurements on liquid insulation samples, maximum voltage 10kV. Comes in rugged enclosure.

16 Miscellaneous

16.1 Instrument Storage

During day to day use the instrument can be switched off at the mains switch located above the mains socket on the front panel of the instrument.

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. It is recommended to close the lid for storage in order to protect the device from dust and dirt.

16.2 Care and Maintenance

The Midas micro 2883 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 cables should be periodically checked for damage. If any damage to the insulation is detected then a new measuring or HV cable should be ordered from Haefely Hipotronics.

16.2.1 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 (Trio, Chlorethene, 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.

16.2.2 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, a full calibration can only be performed at Haefely Hipotronics factory. It is however possible to perform a standard check and calibration at the local service point. An updated calibration report will be issued. Please contact support@tettex.com for more information about calibration services.

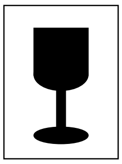
16.2.3 Changing Fuses

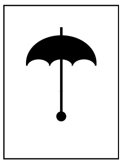
Before changing the main fuse, remove the mains power cord. Fuses should only be replaced with the same type and value (Non resettable fuses with 10A / 250VAC / 5x20mm)

16.3 Packing and Transport

The packing of the MIDAS micro 2883 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

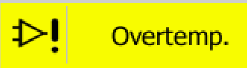
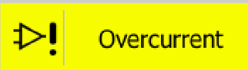
16.4 Recycling

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 aluminium) and synthetic materials. The various component parts can be separated and recycled, or disposed of in accordance with the associated local rules and regulations.

The Standard Capacitor contains SF6 (Sulphur hexafluoride) for insulation. SF6 is a greenhouse gas and has therefore to be handled with care. In Europe only certified personnel is allowed to reclaim or recover SF6 gas. Please inform about the regulations which apply for your country.

17 Trouble Shooting

Problem	Solution
No high voltage at output The high voltage does not rise when a measurement is started. The **"No Signal from internal reference"**-Error appears.	Check for short circuit between high voltage and ground. Disconnect HV cable from DUT put it somewhere safe and isolated and start HV at 500V. Unplug HV cable and start HV. If the problem persists the device has to be repaired by an authorised service agent.
No Current on Measurement Channel No current can be measured on the selected measurement channel. The **"No Signal on measurement channel"**-Error appears.	Check if all the measuring cables are connected correctly. Make sure the correct channel is selected. If you are measuring a very small capacitance it is possible, that the warning shows. Only keep on measuring if you are sure, that everything is connected correctly!
Problems when measuring GST Values of GST measurement are wrong or the algorithms do take a long time to realize a measurement.	Check if there is any connection between the V point and GND. Be aware that also the shield of the coaxial cable is connected to the V point.
The yellow Amplifier Overtemperature error symbol appears 	The amplifier has turned off due to an overtemperature. Please let the device cool off for some time before switching on the HV source again.
The yellow Amplifier Overcurrent error symbol appears 	The amplifier has turned off due to a detected overcurrent on its output. This may be due to a flashover at the high voltage. Please check if all the elements with high voltage have enough distance from any other conducting parts. Make sure that the DUT did not short circuit. The warning persists until you restart a measurement or cancel it by clicking on the yellow symbol.
The yellow Amplifier Overpower error symbol appears 	The amplifier has turned off because the limit of real power at its input (800W) has been exceeded. This may happen if the DUT has a huge tan delta (small R in parallel or big R in series). It may also indicate a flashover or the beginning of one. Please check the test setup. The warning persists until you restart a measurement or cancel it by clicking on the yellow symbol.
The yellow Amplifier Transient error symbol appears 	The amplifier has detected a transient on the signal and has shut down in order to prevent the transient from causing overvoltages on the high voltage side of the internal transformer.

Warning	Explanation
IniFile is corrupted. Default values will be used.	The ini File is corrupted due to an error during file handling (e.g. power off while writing). The ini File will be restored from a default file. Calibration values will still be correct and measurement accurate. Only user settings like the last connection or the selection of measurement values will be reset to default values.
File with default values is damaged!	The default file used to restore the ini file is also

Measurements are not accurate. Please contact\nsupport@tettex.com.	corrupted. This is a very improbable exception. Because the calibration values are missing the accuracy cannot be guaranteed anymore. Please contact support@tettex.com in order to restore the values from our device database.
Internal Communication broken	The communication on the measuring board is broken. Turn the device off and on again. If the error persists please contact support@tettex.com.
Internal Communication error	The communication with the measuring board was erroneous. If this is a single event no measures have to be taken. If the error persists please contact support@tettex.com.
PT100 temperature sensor of the internal power transformer is erroneous. No temperature surveillance is possible anymore. Fail free operation under heavy load is no longer guaranteed! Use on your own risk.	If a broken temperature sensor of the power source is detected the user is warned. The temperature surveillance will no longer be working. If the power source heats up uncontrolled it may be damaged. The device can still be used to export files or analyze the results. It should however be avoided to switch on the power source. Please contact support@tettex.com.
Communication to Amplifier failed This is not a safety relevant problem. You can continue measuring safely. To fix communication please restart the device.	The communication protocol with the amplifier got stuck. This condition does not represent any danger. All safety relevant functions are still working. Only in case of an amplifier error the reason of the error cannot be determined. After a restart of the device (leave the device off for about 10 seconds) the problem should be solved.
The file XY was not saved before. Do you want to save file changes first?	The device was powered off without saving the current file. The user is asked if he wants to restore the values from the last auto save made in the background. Click yes to restore to values in the auto save file.

18 Customer Support

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

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

HAEFELY HIPOTRONICS

Customer Service - Tettex

Birsstrasse 300

CH-4052 Basel

Switzerland

Tel: +41 61 373 4422

Fax: +41 61 373 4914

E-mail: support@tettex.com

We prefer contact via email. Then the case is documented and traceable. Also the time zone problems and occupied telephones do not occur.

Complete information describing the problem clearly helps us to help you:

Failure description

Used settings

DUT type

Firmware Version

Serial Number

MAC address

Printouts, Pictures

Firmware Version & Serial No. can be found in “Setup – Miscellaneous”, see chapter 12.2 Miscellaneous Tab.

19 Conformity

HAEFELY
HIPOTRONICS

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 2004/108/EC and the low voltage directive 2006/95/EC.

Product: **Insulation diagnosis set MIDAS micro 2883**

Description: The universal MIDAS micro is a measuring instrument for power / dissipation factor / tan δ and capacitance testing on high voltage components in the field and in the factory.

Standards: EN 61010-1: 2010
EN 61326-1: 2013

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

Basel, February 13, 2014

(Signature)

Haefely Test AG, Birsstrasse 300, CH-4052 Basel / Switzerland
www.haefely.com

20 Applications Guide

This chapter contains important information regarding construction of the test circuit and the individual test modes depending on the device under test.

Selected circuits for specific test objects are presented for further information. Unfortunately it is not possible to provide a test circuit for every customer specific test object as this would exceed the capacity of this manual.

If this chapter is studied carefully, and the function of the measuring instrument with the individual test modes is understood, then it will be simple to find the relevant test circuit for a special application.

20.1 Bushings

The most important function of a bushing is to provide an insulated entrance for an energized conductor into an equipment tank or chamber. A bushing may also serve as a support structure for other energized parts of an equipment.

Generally two types of bushings are available:

Condenser type

- Oil-impregnated paper insulation with interspersed conducting (condenser) layers or oil-impregnated paper insulation, continuously wound with interleaved lined paper layers.
- Resin-bonded paper insulation with interspersed conducting (condenser) layers.

Non-condenser type

- Solid core, or alternate layers of solid and liquid insulation.
- Solid mass of homogeneous insulating material (e.g. solid porcelain).
- Gas filled.

The primary insulation of outdoor bushings is contained in a weatherproof housing, usually porcelain or silicone. The space between the primary insulation and the weather shed is usually filled with an insulating oil or a compound (plastic, foam, etc.). Bushings also may use gas such as SF_6 as an insulating medium between the center conductor and the outer weather shed.

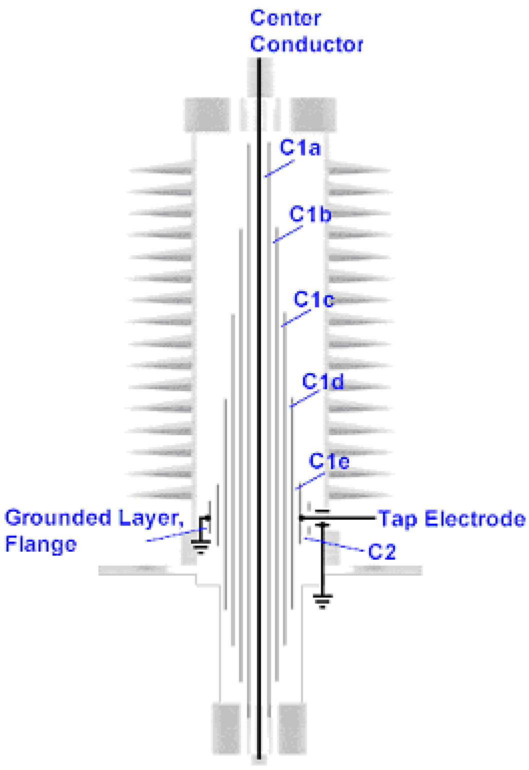
Bushings may be classified as being equipped or not equipped with a potential tap (sometimes also called "capacitance" or "voltage" tap) or a dissipation factor test tap (power factor tap). Usually high voltage bushings are fitted with potential taps while medium or low voltage bushings are equipped with dissipation factor taps.

In higher voltage designs, the potential tap may be utilized to supply a bushing potential device for relay and other purposes. Therefore these are capable of withstanding fairly high voltages.

Potential taps also serve the additional purpose of permitting a dissipation factor test on the main insulation of a bushing without the need to isolate the upper and lower terminals from the associated equipment and connected deenergized bus. Dissipation factor taps are not designed to withstand high potential since their purpose is solely to provide an electrode for making a dissipation factor test on the bushing C1 insulation.

The dissipation factor tap is normally designed to withstand only about 500V while a potential tap may have a normal rating of 2.5kV to 5kV. Before applying a test voltage to the tap, the maximum safe test voltage must be known and observed. An excessive voltage may puncture the insulation and render the tap useless.

A bushing without a potential tap or power-factor tap is a two-terminal device which is normally tested overall (center conductor to flange). If the bushing is installed on equipment like circuit breaker, transformers or cap banks the overall measurement will include all connected and energized insulating components between the conductor and ground.



In principle a condenser bushing is a series of concentric capacitors between the center conductor and ground sleeve or mounting flange.

A conducting layer near the ground sleeve may be tapped and brought out to a tap terminal to provide a three-terminal specimen.

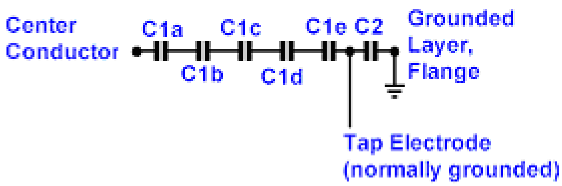
The tapped bushing is essentially a voltage divider.

Note:

Equal capacitances (C1a..C1e) produce equal distribution of voltage from the energized center conductor to the grounded condenser layer and flange.

The tap electrode is normally grounded in service except for certain designs and bushings used with potential device.

For bushings with potential taps, the C2 capacitance is much greater than C1 For bushings with power-factor tap , C1 and C2 capacitances may be the same order of magnitude.



Construction of a bushing

In the dissipation factor tap design, the ground layer of the bushing core is tapped and terminated in a miniature bushing on the main bushing mounting flange. The tap is connected to the grounded mounting flange by a screw cap on the miniature bushing housing. With the grounding cap removed, the tap terminal is available as a low-voltage terminal for a UST measurement on the main bushing insulation, C1 conductor to tapped layer.

In some bushing designs the tapped layer is brought out into an oil-filled compartment. The potential tap is allowed to float in service. A special probe is inserted through an oil filling hole to make contact with the tapped layer, to permit a measurement.

A bushing is a relatively simple device and field test procedures have been evaluated to facilitate the detection of defective, deteriorated, contaminated or otherwise damaged insulation. The most important types of tests applicable to bushings are:

Overall Test (Centre Conductor to Flange, C1/C2)

Centre Conductor to Tap Test (C1)

Tap Insulation Test (Tap to Flange, C2)

Hot Collar Test (Collar to Center Conductor)

Due to the caution statement mentioned above, it is important to note that for tap-insulation tests the applied voltage should not exceed 5 kV for potential taps and 500 V for dissipation factor taps.

For the overall and the center conductor to tap test a convenient voltage at or below the bushing nameplate rating should be chosen.

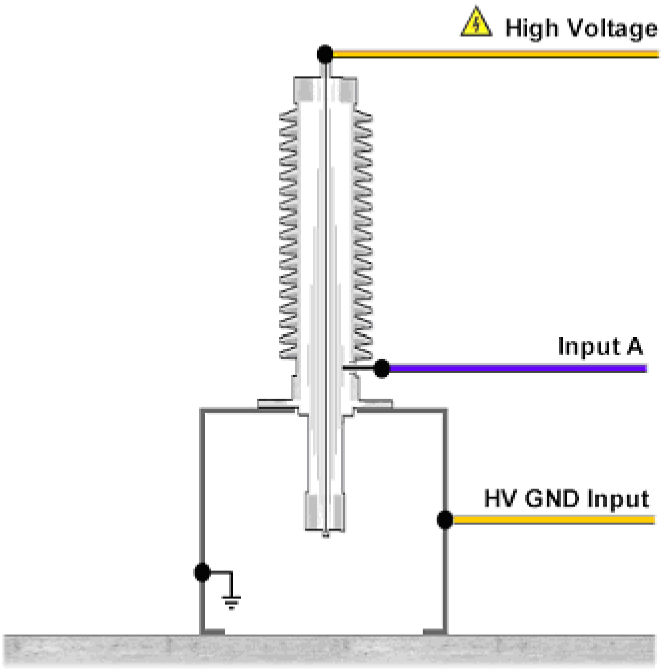
The hot collar test should be performed at a test voltage of about 10kV.

20.1.1 Spare Bushings

For testing a spare bushing care must be taken in the method used to hoist the bushing.

The bushing should be mounted in a grounded metal rack with nothing connected to the terminals. Tests should not be performed with the bushings mounted in wooden crates or lying on a floor. Otherwise the test results can be affected by the wood or the cement floor.

It is also important to ensure that the bushing centre conductor is not in contact with a foreign material (sling, rope, etc.).



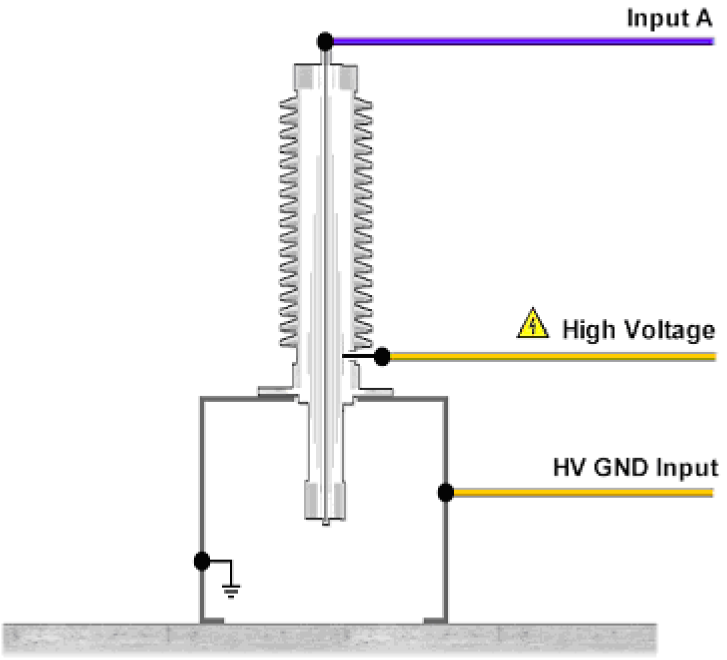
The overall test for spare bushings, with or without taps, can be performed with the GST gA+B (INPUT A must not be connected).

With this test mode the overall capacitance is measured C = C1 in series with C2.

The main insulation (C1) of bushings equipped with taps can be tested separately (INPUT A to tap). The C1 insulation is measured using the UST A mode.

With this test connection the tap insulation capacitance (C2) is not measured directly but can be calculated from the GST gA+B and the UST A mode using following formula: $C2 = (C \cdot C1) / (C1 - C)$.

Spare Bushing Insulation Test



The tap insulation (C2) of bushings equipped with taps, can be measured directly.

As illustrated in the figure beside, the High Voltage and the INPUT A cable must be interchanged.

Using the GST gA+B mode will bypass the main insulation (C1) and measure the tap insulation (C2).

Warning: Check the manufacturer's recommendation for max. tap test voltage

Spare Bushing Tap Insulation Test

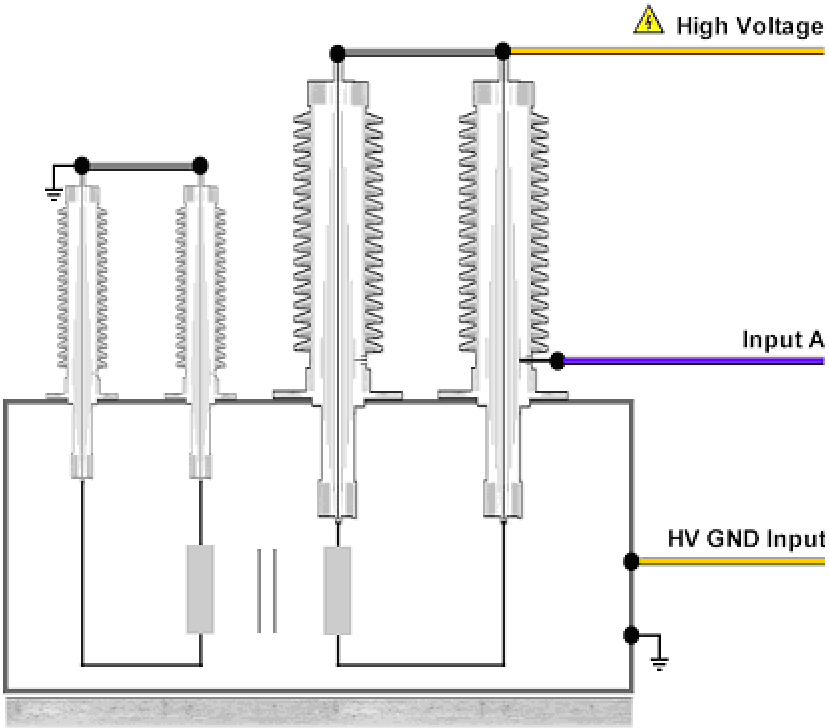
20.1.2 Installed Bushings

Overall Test (Centre Conductor to Flange)

If a bushing is mounted on an equipment, the overall measurement method would include all conduction and insulation elements connected between the bushing center conductor and ground. Therefore the overall method is not recommended for separate tests on bushings, unless the bushing conductor can be completely isolated or the bushing has no tap.

Center Conductor to Tap, C1

Most high-voltage condenser-type bushings are equipped with either potential or power-factor test taps. These permit separate tests on the main bushing insulation (commonly referred to as C1) without the need to disconnect a bushing from the equipment or bus to which it is connected.



The C1 insulation is measured by the UST A mode. The connection is shown in the figure beside.

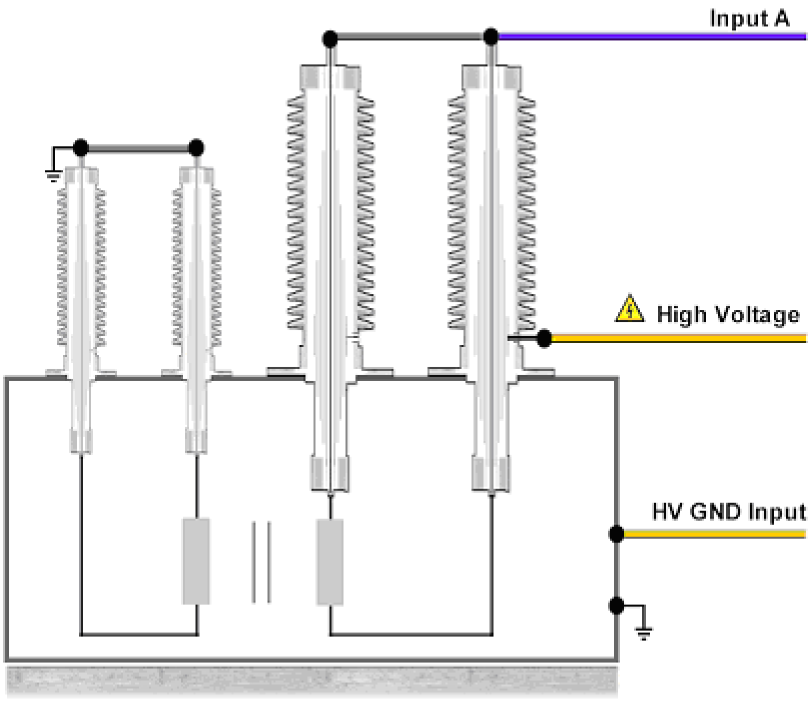
The values are measured in the conventional manner, and the dissipation factor is calculated and corrected for temperature. For a bushing in a power or distribution transformer the average temperature of the transformer top-oil and ambient air temperature should be used. For bushings mounted in oil circuit breakers the C1 dissipation factor should be corrected using the air temperature.

C1 Insulation test of bushing in transformer

During measurements on bushings in transformers, all terminals of the windings to which the bushings are connected must be tied together electrically. Otherwise higher-than-normal losses may be recorded due to the influence of the winding inductance. Also, for safety the bushings associated with all windings not energized should be grounded and not left floating.

Tap-Insulation Test (Tap to Flange, C2)

Before starting any measurements the test engineer must carefully consider the type of tap and its corresponding maximum rated voltage. The maximum permissible test voltage is usually designated by the manufacturer (generally between 500 V and 2 kV).



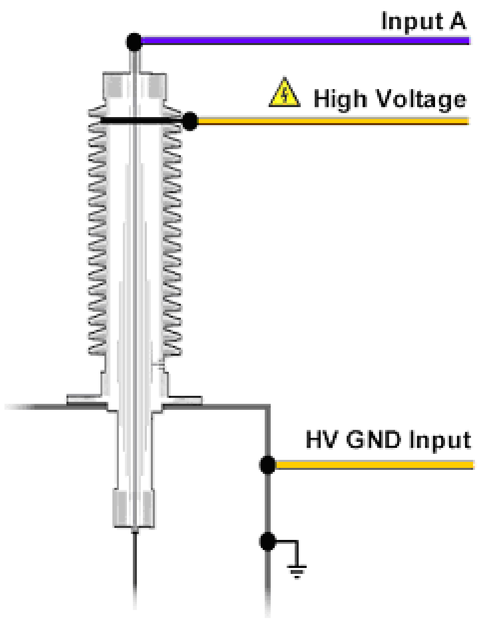
In analogy to the tap insulation test on spare bushings the C2 insulation is measured by the GST gA+B mode. The connection is shown beside.

For the capacitance C2 (tap to flange) the dissipation factor is calculated but normally not corrected for temperature.

Tap-insulation (C2) test on bushing in transformer.

Hot Collar Test

The dielectric losses through the various sections of any bushing or pothead can be investigated by means of a hot collar test which generates localized high-voltage stresses. This is accomplished by using a conductive hot collar band designed to fit closely to the porcelain surface, usually directly under the top petticoat, and applying a high voltage to the band. This test provides a measurement of the losses in the section directly beneath the collar and is especially effective in detecting conditions such as voids in compound filled bushings or moisture penetration since the insulation can be subjected to a higher voltage gradient than can be obtained with the normal bushing tests.



The Hot Collar Test is made by UST A mode and the bushing need not be disconnected from other components or circuits. Make sure that the collar band is drawn tightly around the porcelain bushing to ensure a good contact and eliminate possible partial discharge problems at the interface.

Hot Collar test on bushing in transformer.

20.1.3 Measuring Data Interpretation

Condenser Bushings

The dissipation factor and capacitance recorded are compared with one or more of the following:

- Nameplate data.
- Results of prior tests on the same bushing.
- Results of similar tests on similar bushings.

Dissipation factors for modern condenser bushings are generally in the order of 0.5% after correction to 20°C. They should be within twice the nameplate value. Increased dissipation factors indicate contamination or deterioration of insulation.

Capacitances should be within +/- 5 .. +/- 10% of nameplate value, depending upon the total number of condenser layers. Increased capacitance indicates the possibility of short-circuited condenser layers. Decreased capacitance indicates the possibility of a floating ground sleeve, or open or poor test tap connection.

Negative dissipation factors accompanied by small reductions in capacitance or charging current are experienced occasionally, and may result from unusual conditions of external surface leakage or internal leakages resulting from carbon tracks.

On bushings equipped with taps, the measurement on C1 is supplemented by a Tap-Insulation test on C2. Test potential may have to be reduced from 2.5 kV depending upon the tap rating. The dissipation factor of tap insulation is normally not corrected for temperature. Dissipation factors recorded for tap insulation are generally on the order of 1%. Results should be compared with those of earlier tests or with results of tests on similar bushings.

Capacitances recorded for tests on potential taps should also be checked against nameplate values, if available. Decreased capacitance indicates the possibility of a floating ground sleeve, or poor test tap connection.

Dry-Type Porcelain Bushings

Bushings of this design may be used in circuit breakers or transformers, or as roof or wall bushings. They are not equipped with special test electrodes or facilities, so that the only test applicable is the Overall method, conductor to mounting flange.

The test results are analysed and graded on the basis of comparison of results among similar . bushings and with results recorded for previous tests. Abnormally high losses and dissipation factor result from:

- Cracked porcelain
- Porous porcelain which has absorbed moisture (not common in modern porcelain)
- Losses in the secondary insulations, such as varnished cambric
- Corona around the centre conductor.
- Conducting paths over the insulation surfaces to ground.
- Improper use or bonding of resistance coatings or glazing on internal porcelain surfaces.

Cable-Type Bushings

Overall dissipation factor and Hot-Collar losses are relatively high because of inherently high losses in the cambric insulation. Test results should be compared among similar bushings and with those recorded for previous tests. Abnormally high losses can result from moisture entering the top of the bushing and contaminating cambric and compound, migration of oil into the compound through a bottom seal, cracked porcelain, etc.

Hot-Collar Test

The losses recorded should be less than 100mW. If the current or watts-loss is appreciably higher than normal, then a second test is made after moving the collar down one petticoat. This procedure can be followed as far down the bushing as necessary to determine how far down the fault has progressed.

20.2 Transformers

20.2.1 Power and Distribution Transformers

The dissipation factor test for distribution transformers (rated ≤ 500kVA) and power transformers (rated > 500kVA) is a very comprehensive test for detecting moisture, carbonization, and other forms of contamination of windings, bushings, and liquid insulations.

Power and distribution transformers exist as single-phase or three-phase design. For insulation purposes transformers can be further classified as dry type which have air or gas as insulation and cooling medium, or as liquid-filled constructions which have mineral oil, Askarel® or other synthetic materials.

The scope of the dissipation factor test for transformers is to determine the capacitance (insulation) between the individual windings and between the windings and ground.

To eliminate any effect of winding inductance on the insulation measurements all terminals of each winding, including neutrals, must be connected together. Check also for possible arrester elements in the tap changer.

Before any measurement is performed the transformer must be deenergized and completely isolated from the power system. The transformer housing must be properly grounded.

References and standards for the dissipation factor tests can be found in:

IEC60076-1 (2000) clause 10.1.3 "Measurement of the dissipation factor of the insulation"

IEEE Std C57.12.90-1999 clause 10.10 "Insulation power-factor tests"

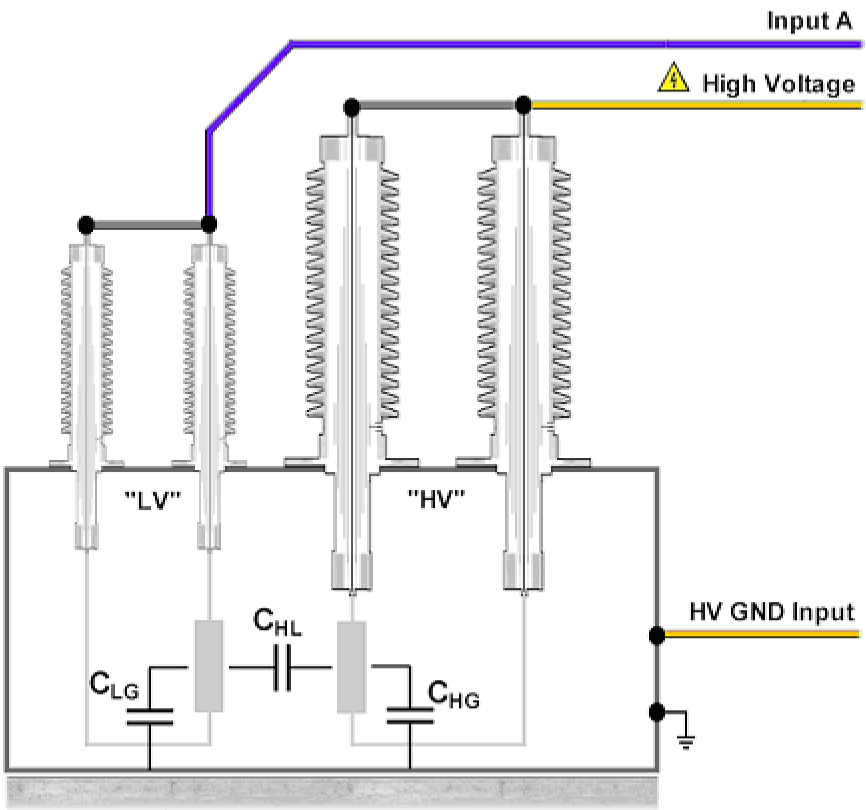
Test Levels

The decision about the applied test voltage is in most cases easy since the tested equipment is generally rated above 12 kV. In case of equipment rated 12 kV or lower, consideration should be given to include testing at slightly above (10..25%) the operating line-to-ground voltage.

IEEE C57.12.90 recommends that, for insulation dissipation factor tests, the voltage should not exceed one-half the low-frequency test voltage given in IEEE C57.12.00. The lowest low-frequency test voltage given in C57.12.00 is 10 kV which correspond to a nominal system voltage of 1.2 kV. Therefore, in accordance with IEEE, an insulation dissipation factor test voltage of 5 kV could be applied to 1.2 kV transformer.

The following sections try to illustrate three typical applications of testing the insulation properties of transformers. First an ordinary two winding transformer is presented, then an autotransformer is visualized and finally a three winding transformer is explained.

Two Winding Transformers (3 phase and single-phase)



Measurement connections of a two windings transformer for measurement of C_{HG} and C_{HL}

Test Connections

Sequence Line	DUT	INPUT A to	INPUT HV GND to	Test Mode	High Voltage to
1	CHL	LV	Tank GND	UST A	HV
2	CHG	LV	Tank GND	GST gA+B	HV
3	CLG	HV	Tank GND	GST gA+B	LV
4	CLG + CHG	-	Tank GND	GST gA+B	LV + HV

Note: Test line #4 can be used to inter-check the measurement results. (#4 = #2 + #3). Additional measurements in other test modes can be executed to inter-check the measurements results.

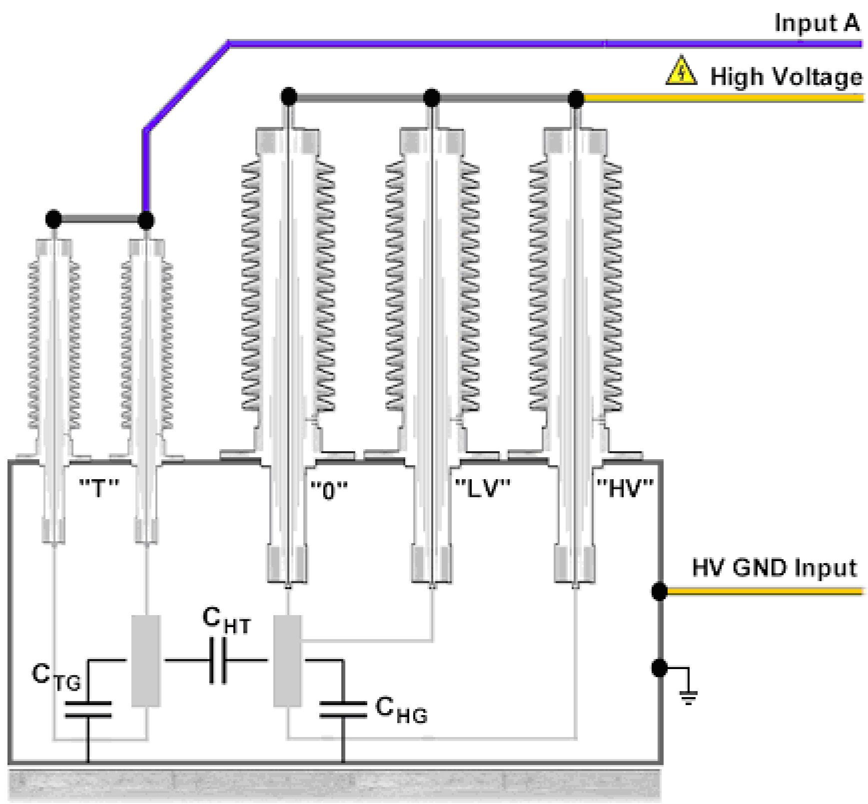
Autotransformers (3 phase and single-phase)

Contrary to the two-winding transformer the windings of an autotransformer cannot be separated. The winding of an autotransformer is a combination of the high- and low-voltage windings (HV and LV, see figure below).

For testing the insulation of an autotransformer all seven bushings (three bushings for a single-phase unit) have to be connected together (HV1+HV2+HV3+LV1+LV2+LV3+0).

For a conventional autotransformer without a tertiary winding only an overall test to ground can be performed (C_{HG}).

If an autotransformer is equipped with a tertiary winding which is accessible, the test procedure is exactly the same as described in section "Two Winding Transformer".



Measurement connections of an autotransformer with tertiary winding for measurement of C_{HG} & C_{HT}

Test Connections

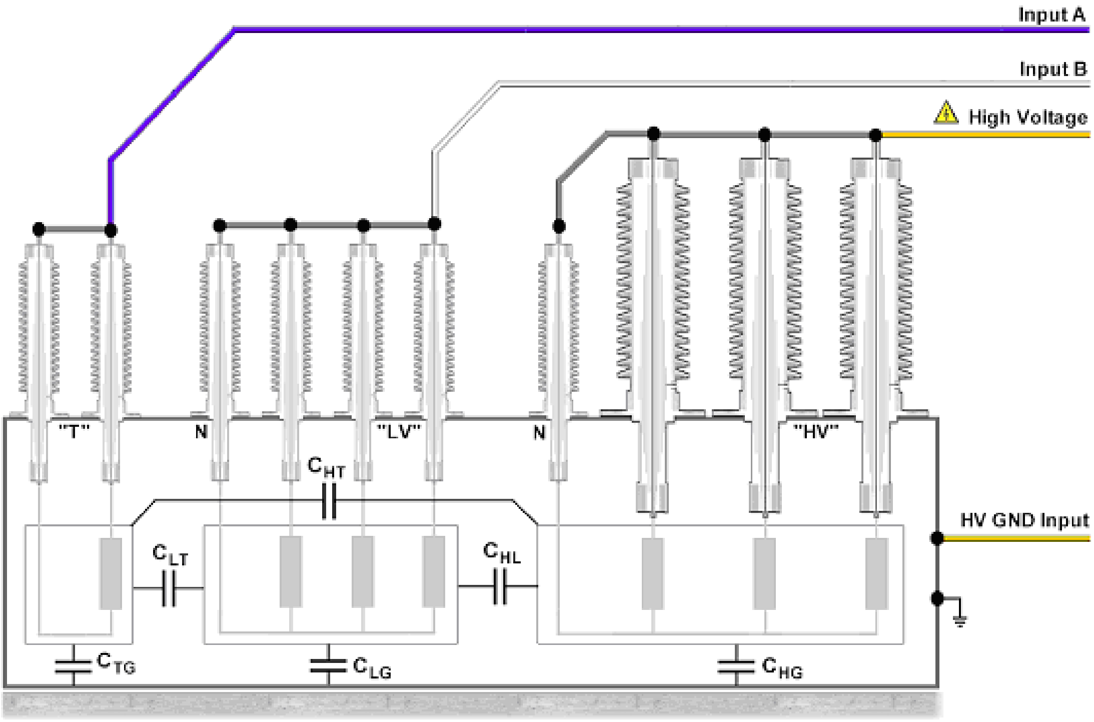
Seq.line	DUT	INPUT A to	INPUT HV GND to	Test Mode	High Voltage to
1	CHT	T	Tank GND	UST A	HV+LV+0
2	CHG	T	Tank GND	GST gA+B	HV+LV+0
3	CTG	HV+LV+0	Tank GND	UST A	T
4	CTG + CHG	-	Tank GND	GST gA+B	HV+LV+0+T

Note: Test line #4 can be used to inter-check the measurement results. (#4 = #2 + #3). Additional measurements in other test modes can be executed to inter-check the measurements results.

Three Winding Transformers (3 phase and single-phase)

The test technique for a three-winding transformer is an extension of the two-winding transformer test procedure.

In some cases a three-winding transformer is so constructed that one of the interwinding capacitances is practically non-existent. This condition may be the result of a grounded electrostatic shield between two windings, or of a concentric-winding arrangement which places one winding between two others. The effect of the grounded shield of the sandwiched winding is to effectively eliminate the interwinding capacitance except for stray capacitances between bushing leads.



3 phase, 3 winding transformer in Yn-Yn formation with tertiary winding. Measurement connections for measurement of C_{HG} , C_{HT} and C_{HL}

Test Connections

Sequence line	DUT	INPUT A to	INPUT B to	INPUT HV GND to	Test Mode	High Voltage to
1	C_{HT}	T	LV	Tank GND	UST A	HV
2	C_{HG}	T	LV	Tank GND	GST gA+B	HV
3	C_{HL}	T	LV	Tank GND	UST B	HV
4	C_{LG}	T	H	Tank GND	GST gA+B	LV
5	C_{TG}	HV	LV	Tank GND	GST gA+B	T
6	C_{LT}	HV	LV	Tank GND	UST B	T
7	C_{HG} + C_{LG} + C_{TG}	-	-	Tank GND	GST gA+B	HV+LV+T

Note: Test line #7can be used to inter-check the measurement results. (#7= #2 + #4 + #5) additional measurements in other test modes can be executed to inter-check the measurements results.

Measuring Data Interpretation

If available the dissipation factor and the capacitances should be compared with factory data, with previous test results and with test results on similar units.

Capacitance is a function of winding geometry, and is expected to be stable with temperature and age. A change of capacitance is an indication of winding movement or distortion such as might occur as a result of a through fault. Such a fault affects mainly the C_{LG} and C_{HL} insulations.

Increased dissipation factor values normally indicate some general condition such as contaminated oil. An increase in both dissipation factor and capacitance indicates that contamination is likely to be water.

Modern oil-filled power transformers should have insulation power factors of 0.5% or less at 20°C. There should be a justification by the manufacturer for higher values, and assurance that they are not the result of incomplete drying. Older power and distribution transformers may have power factors higher than 0.5%.

Abnormal power factors are occasionally recorded for inter-winding insulations of two-winding transformers. These may be the result of improper (high-resistance) grounding of the transformer tank, or the use of grounded electrostatic shielding between transformer windings. In this case, as a result of the ground shield, the inter-winding capacitance is practically non-existent except for stray capacitances between bushing leads.

Although the bushings are included in C_{LG}, C_{HG}, the effect of a single bushing on the measuring value may be small, depending upon the relative capacitance of the bushing and the overall C_{LG}, C_{HG} component. It is possible that a defective bushing may go undetected in an overall test because of the masking effect of the winding capacitance. It is imperative that separate tests should be performed on all transformer bushings.

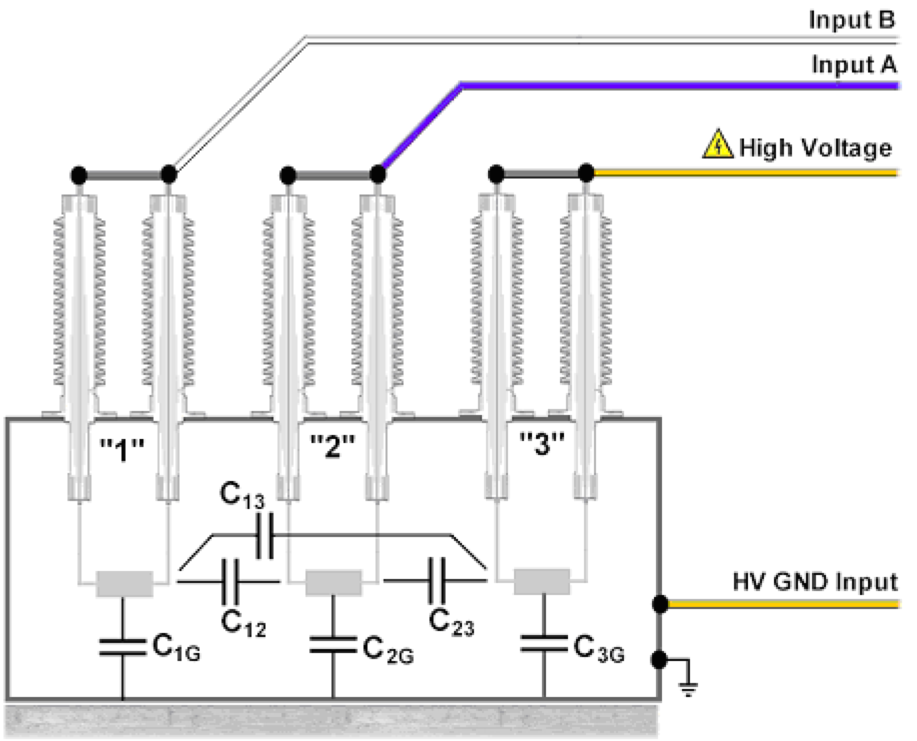
The Transformer windings must remain short-circuited for all bushing tests and all bushings connected to deenergized windings shall be connected to the V-point (if not done by the test mode).

Bushings with potential or dissipation factor taps may be tested separately. See also section “Test Procedure Bushings”.

20.2.2 Shunt Reactors

Oil-filled shunt reactors are used in HV systems to limit over-voltage surges associated with long transmission lines. The shunt reactor compensates the capacitive generation on power lines to avoid non-controlled voltage rise especially on lightly loaded lines.

Two configurations of shunt reactors are available: either each phase is contained in its own separate tank or all three phases are contained in a common tank.



3 phase shunt reactor; measurement connections for measurement of C_{3G}

Test Connections

Sequence Line	DUT	INPUT A to	INPUT B to	INPUT HV GND to	Test Mode	High Voltage to
1	C_{1G}	2	3	Tank GND	GST gA+B	1
2	C_{12}	2	3	Tank GND	UST A	1
3	C_{13}	2	3	Tank GND	UST B	1
4	C_{23}	1	3	Tank GND	UST B	2
5	C_{2G}	1	3	Tank GND	GST gA+B	2
6	C_{3G}	2	1	Tank GND	GST gA+B	3
7	$C_{1G} + C_{2G} + C_{3G}$	-	-	Tank GND	GST gA+B	1 + 2 + 3

Note: For a single-phase shunt reactor only the overall measurement is made, by short-circuiting the winding and making a GSTg A+B measurement (above table, row #1)

The overall winding dissipation factors should be corrected for top oil temperature. The dissipation factors are analyzed in the same manner as power transformers.

The test results can be supplemented by tests on the bushings, on oil samples, and by excitation-current measurements on the individual phases.

Sometimes it is advantageous to investigate abnormal results by making a series of tests at several voltages, to determine if the condition causing the abnormal result is nonlinear or voltage sensitive within the range of available Test Levels. This might include increasing the test voltage up to 12kV.

20.2.3 Current Transformers

Current transformers (CTs) convert high transmission line current to a lower, standardized value to be handled by instrumentation. The measures are used for network control, protection and revenue metering.

Current transformers have voltage ratings from several kilovolts up to the highest system voltages now in operation. Conventional CTs are oil-filled but since several years CTs are also available as a dry type version, normally filled with SF_6.

Test Voltage

Current transformers which are rated 12 kV and above can be tested with an applied voltage of 10 kV. For units rated below 12 kV a convenient test voltage should be chosen, which is equal to or below the nameplate rating.

For dry type CTs a the test voltage of 10% to 25% above line-to-ground operating voltage can be applied.

Sometimes it might be useful to investigate abnormal results on the units by making a series of tests at several voltages to determine if the condition causing the abnormal result is nonlinear or voltage sensitive within the range of possible Test Levels. For example a test sequence of 2 kV, 10kV and 12kV may be used.

Test Procedure

Current transformers are tested in the same manner as two winding transformers (see section “Power and Distribution Transformers”).

As for all transformer tests, the device under test must first be isolated, deenergized and grounded. For the dissipation factor test the high voltage cable should be applied to the shorted terminals of the primary winding. The secondary winding should be shorted and grounded.

For current transformers which are tested in storage, the frame must be grounded externally.

Some HV CTs are equipped with taps similar to those on bushings. For these units a supplementary test can be performed, in addition to the overall test. The main insulation C1 (between tap and conductor) and the tap insulation C2 (between tap and ground) can be tested separately. Current transformers with such taps often have nameplate values of dissipation factor and capacitance C1, C2.

As already indicated in section “Bushings”, the test potential applied to the tap must not exceed the voltage rating of the tap.

Measuring Data Interpretation

CT dissipation factors are corrected based on the ambient temperature at the time of test. Oil-filled units use the curve “Oil-Filled Instrument Transformers” while askarel-filled units are corrected using the curve “Askarel”. Dry-type units are not corrected for temperature.

The corrected dissipation factors should be compared with previous test results, with data recorded for other similar units on the system and against factory or nameplate data.

Dry-type CTs can be further analyzed base on dissipation-factor tip-up.

20.2.4 Voltage Transformers

A huge variety of different kinds of voltage (or potential) transformers makes a complete disquisition in this manual impossible. Therefore only one of the most famous and widespread voltage transformers is presented here. It is the capacitor voltage transformer (CVT) as available for example by ABB (type CPA) or by Trench (type WE).

A capacitor voltage transformer consists basically on a capacitor voltage divider and an inductive/electromagnetic unit. The electromagnetic unit includes a transformer and a reactor whose inductance is adjusted in resonance to the equivalent capacitance of the voltage divider. The secondary voltage of the electromagnetic unit is proportional to the primary voltage and differs in phase from it by an angle which is approximately zero.

The appropriate standard for testing capacitor voltage transformers are IEC 600186 and IEC 600358.

Test Procedure

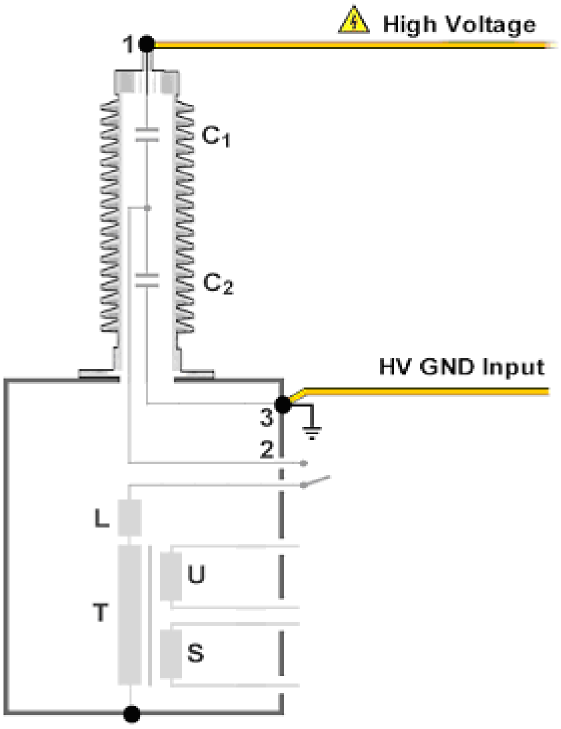
Before any attempt is made to measure a voltage transformer, the unit should be isolated, deenergized and grounded effectively.

For test purpose the inductive unit of a capacitor voltage transformer can be disconnected from the capacitor voltage divider. This allows beside the overall test (voltage ratio, phase displacement) separate measurements about the condition of the voltage divider and the electromagnetic unit.

A test procedure with the corresponding test modes is shown in the figure below. The connection between the intermediate voltage of the voltage divider and the tuning reactor must be opened. Then the capacitance and the loss factor of the capacitor voltage divider can be measured as outlined in the table below.

Since the high voltage winding of the transformer is not capacitive graded, a measurement of the loss angle (tan δ) will give no significant results. More meaningful tests would be secondary/ adjustment winding resistance measurements and oil sample analysis.

The applied test voltage for the capacitor voltage divider should be chosen between 90 – 110% of the rated voltage. In order to reveal any change in capacitance due to the puncture of one or more elements, a preliminary capacitance measurement can be made at a sufficiently low voltage (less than 15% of rated voltage). If the rated voltage exceeds the maximum available test voltage, measurements should be performed at the maximum test voltage.



C_1, C_2	Capacitor voltage divider
L	Tuning reactor
T	Primary winding
S	Secondary winding
U winding	Ferro resonance damping

Capacitor voltage transformer test procedure

Test Connections

DUT	Test Mode	High Voltage to	INPUT A to	INPUT HV GND to
C1 in series with C2	GST gA+B	1	-	3

Measuring Data Interpretation

Measurement results should be compared with earlier measurements on the same apparatus, on similar units and with manufacturer data.

Generally the measured capacitance value should not differ from the rated capacitance by more than –5% to +10%. The ratio of the capacitances of any two units forming a part of a capacitor stack shall not differ by more than 5% from the reciprocal ratio of the rated voltages of the units.

The capacitor losses (tan δ) should be agreed upon between manufacturer and purchaser.

If the dielectric system of the capacitor divider varies with the voltage, it can be meaningful to perform measurements at several voltages to determine if the effect is nonlinear or voltage sensitive.

20.2.5 Excitation Current Measurement

The excitation current measurement can be used to detect short-circuited turns, poor electrical connections, core de-laminations, core lamination shorts, tap changer problems and other possible windings and core problems in the transformer. In principle the test measures the current needed to magnetize the core and generate the magnetic field in the windings.

The excitation current test should be performed before any DC tests. Excitation current tests should never be conducted after a DC test has been performed on the transformer. Results will be incorrect because of residual magnetism of the core left from the DC tests.

Measurement Procedure

Excitation current measurements should be performed at the highest test voltage possible within the range of the test instrument. Nevertheless the test voltage should not exceed the voltage rating of the windings.

The test voltage is normally applied to the high voltage side of the transformer. This minimizes the charging current and deterioration or faults in the secondary windings are still detectable.

The secondary winding is always left open.

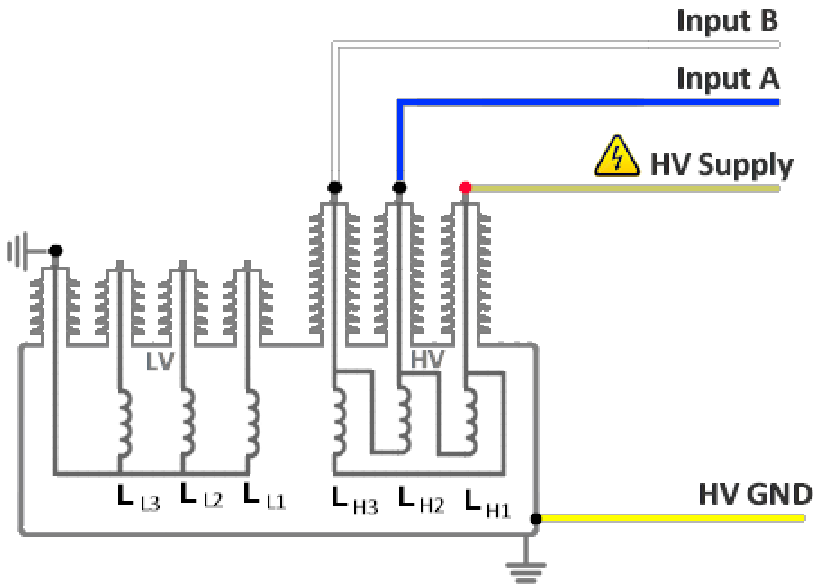
Due to induced voltages during the excitation current test, caution should be exercised in the vicinity of all transformer terminals.

Built in current transformers must be shorted during the test and condenser bushing taps should be earthed.

The test connection for measuring excitation current on a three-phase transformer depends on the transformer winding configuration (Y, Yn, D, etc.).

The neutral on the low voltage winding should be grounded if present.

Excitation Current Measurement on a D-yn transformer

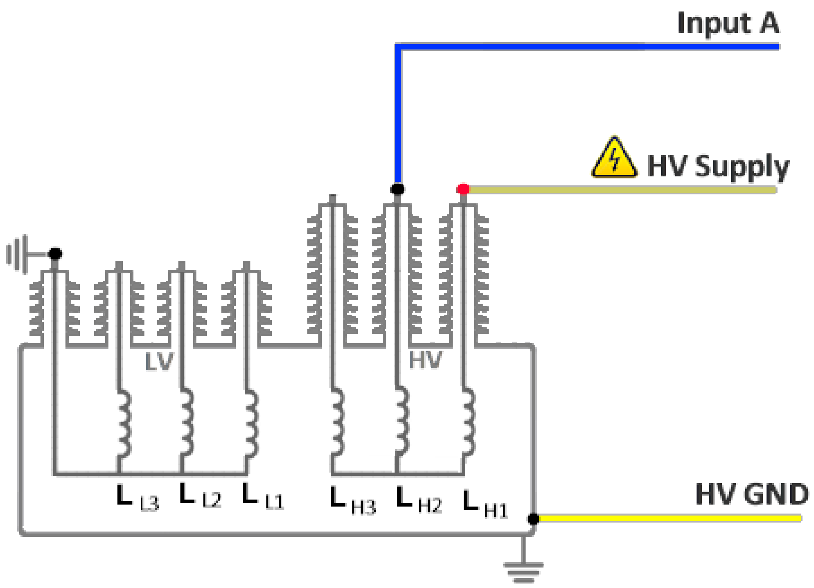


Excitation current measurement connection for L_{H1} and L_{H2} measurement on a D-yn transformer

Test Connections

DUT, excitation current through	High Voltage to	INPUT A to	INPUT B to	HV GND INPUT to	Test Mode
L_{H1}	1	2	3	Tank GND	UST A
L_{H3}	1	2	3	Tank GND	UST B
L_{H2}	2	3	1	Tank GND	UST A

Excitation Current Measurement on a Y-y or Y-yn transformer

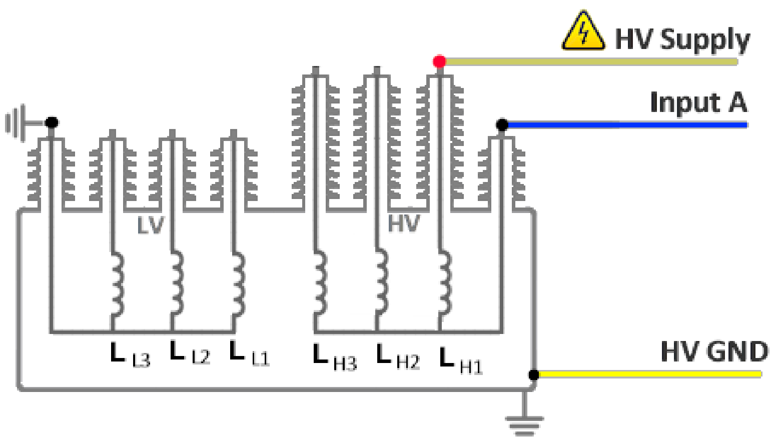


Excitation current measurement connection for L_{H1} + L_{H2} measurement on a Y-y or Y-yn transformer

Test Connections

DUT, excitation current through	High Voltage to	INPUT A to	INPUT B to	HV GND INPUT to	Test Mode
$L_{H1} + L_{H2}$	1	2	-	Tank GND	UST A
$L_{H2} + L_{H3}$	2	3	-	Tank GND	UST B
$L_{H3} + L_{H1}$	3	1	-	Tank GND	UST A

Excitation Current Measurement on a YN-y or Yn-yn transformer



Excitation current measurement connection for L_{H1} measurement on a YN-y or YN-yn transformer

Test Connections

DUT, excitation current through	High Voltage to	INPUT A to	INPUT B to	HV GND INPUT to	Test Mode
L_{H1}	1	N	-	Tank GND	UST A
L_{H2}	2	N	-	Tank GND	UST B
L_{H3}	3	N	-	Tank GND	UST A

Measuring Data Interpretation

On a three-phase, star/delta or delta/star transformer, the excitation current pattern will generally be higher on two phases than on the remaining phase. The lower current in a phase can be attributed to the lower reluctance of the magnetic circuit for the center leg of a three-legged core.

Excitation current $<$ 50 mA	Excitation current $\geq$ 50 mA
Difference between the two higher currents should be less than 10%	Difference between the two higher currents should be less than 5%

In general, if there is an internal problem, the differences between the phases with the higher current will be greater. When this happens, other tests should also show abnormalities, and an internal inspection should be considered. The results, as with all others, should be compared with factory and prior field tests.

20.3 Liquid Insulation

To test liquid insulation a special oil test cell has been constructed. The oil test cell is basically a capacitor with a liquid insulation as a dielectric constant. The test cell is supplied in an insulated case for simple transportation and for use as insulation of the cell from ground during the test. After each test the cell should be cleaned. If the same type of liquid will be tested, it is sufficient to flush the cell by a portion of the new oil sample, or other oil of the same type. If the cell will be used to test a different type of liquid insulation or is dirty, it should be cleaned with a suitable solvent properly. After cleaning with solvent the cell should be dried. The cell shouldn't be wiped out with rags to avoid cotton fibers, etc., to be left in the cell and affect the test results of the sample.

To test a representative sample of liquid insulation any dirt or water in the sample should be avoided.

The volume of the test cell is approximately one liter. It should be filled until there is about 2cm of liquid above the top of the cylinder inside the cell; when the cover is replaced, the cylinder of the inner cell should be covered with liquid. If there is an insufficient amount of liquid in the cell, sparking may take place above the liquid level.

The test cell should be placed either at the bottom of the plastic case, or on a suitable insulating material. The reason for undesirable breakdown could be caused by air bubbles, water, and other foreign material in the cell. To prevent such breakdowns the sample should be allowed to settle down before testing. Air bubbles could evaporate and any foreign particles can settle to the bottom.
By rotating slowly the seated inner cell, air bubbles can be released through holes in the inner cylinder.

The test cell is built on the "Outer Cell Electrode" and the removable "Inner Cell Electrode with Cover"

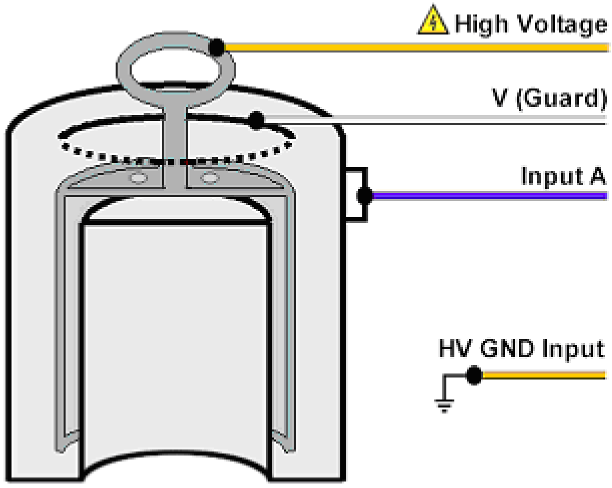
Dissipation factor test cell 6835 for liquid insulation including transportation case

20.3.1 Test Procedure

The high-voltage should be connected to the handle on the inner cell by using the high voltage cable. The V-potential should be connected to the metallic ring on the inner cell cover, using delivered V connection. The outer cylinder should be insulated from ground and connected either to channel A or B of the measuring bridge by using special connection cables. A clearance of several centimeters should be maintained between the HV connection and the ring which is connected to V-potential, so that flashover will not occur between these parts.

The test voltage should be raised to 10 kV. The radial electrode spacing of the cell is about 6.7 mm, the sample should not break down at this voltage unless it is in very poor condition. If a breakdown occurs before 10 kV is reached, then attempt a measurement at some lower voltage (e.g. 2 kV).

Before the sample is tested, its temperature should be taken. The actual temperature should be set in the DUT tab of setup. By choosing the normalized dissipation factor (to 20°C) as a measuring value the automatically calculated value will be recorded.



The Liquid Insulation Test is made by normal UST A mode.
Instead of the HV GND input the Input A is used as low voltage to reach the highest possible accuracy. But to be able to switch HV ON the HV GND Input has to be connected to Ground.

The test cell can be set in the bottom part of the transportation case for this measurement.

Test cell connections

20.3.2 Measuring Data Interpretation

It is suggested that the following guides serve for grading liquid insulation by dissipation factor tests:

Classification	Dissipation factor @ 20 °C		
	Mineral Oil	Synthetic	Others
Good (new)	< 0.05 %	< 0.05 %	< 0.05 %
Used - usually considered satisfactory for continued service	< 0.3 %	< 0.5 %	< 0.3 %
Used - should be considered in doubtful condition, and at least some type of investigation (dielectric breakdown tests) should be made.	> 0.5 %	> 0.5 %	> 0.5 %
Used - should be investigated, and either reconditioned or replaced. Should be investigated to determine the cause of the high power factor.	> 1.0 %	> 2.0 %	> 1.0 %

Note: High dissipation factors indicates deterioration and/or contamination with moisture, carbon, varnish, glyptal, sodium, asphalt compounds, deterioration products, gasket materials or other foreign products.

Mineral Oil

Carbon or asphalt in oil can cause discoloration. Carbon in oil will not necessarily increase the power factor of the oil unless moisture is also present.

Synthetic Insulation Liquid (e.g. Askarel®)

If the high dissipation factor is caused by water or other conducting matter, free chlorides or a high neutralization number, the synthetic oil is probably an operating hazard. If the high dissipation factor is not due to these causes, it is probably not an operating hazard, except that when the dissipation factor is quite high it may result in excessive heating of the device in which it is used. Care should also be taken that the high dissipation factor is not due to dissolved materials from gaskets or insulation necessary for safe operation of the askarel filled device. High dissipation factor due to askarel contamination may mask other defects in askarel-filled units.

The question of what decision to make regarding the condition of the oil depends upon what is causing the high dissipation factor. Dielectric breakdown or water content tests should be made to determine the presence of moisture. The necessity for further tests will depend to a large extent upon the magnitude of the dissipation factor, the importance of the apparatus in which the insulation liquid was used, its rating, and the quantity of insulation liquid involved.

20.4 Cables

Dissipation-factor tests on cables are useful to indicate general deterioration and/or contamination. An increase in dissipation-factor with test voltage may be an indication of a serious general condition of corona in the insulation.

The measured dissipation-factor is an average of the dissipation-factor of each elementary length of insulation. Therefore, if a long cable is measured, an isolated section of the cable having an abnormally high dissipation factor may be completely masked and have no significant effect on the average value.

Effective dissipation-factor tests can be performed on relatively short lengths of cable (especially on shielded cables and unshielded cables enclosed in a metallic sheath). Tests on cables should be performed from both ends.

Testing of cables generally requires additional precautions because the entire device under test is not always visible. Both ends of the cable under test should be clearly identified and isolated.

Avoid prolonged exposure to high humidity conditions before testing because such exposure may result in moisture absorption in the insulating materials. It is desirable to make tests on the winding insulation shortly after shutdown.

Test Levels

Cables rated up to 12 k V should be tested at several voltages up to the operating line-to-ground voltage. For example, a 12 kV insulation class cable on a 10.8 kV systems normally operated at 8 kV should be tested at several voltages up to 8 kV. Additional a test with 10% to 25% above the operating line-to-ground voltage can be performed to accentuate corona and other high-loss conditions.

Cables rated above 12 kV insulation class should be tested at 12 kV or, when an external power supply is available, at the highest test voltage possible.

20.4.1 Test procedures on different cables

Single-Conductor Shielded or Sheathed Cable

The cable should be removed from service and all associated electrical equipment disconnected. The test procedure consists of applying the test voltage to the cable conductor with the cable shield or sheath effectively grounded. The test is made in the UST A mode (HV to conductor, Input A to shield) with the HV GND input connected to earth separately.

Single-Conductor Unshielded and Unsheathed Cables

Measurements on unshielded single-conductor cables are performed using the GST gA+B test mode (HV to conductor, HV GND to earth). The test results may be affected by material which surrounds the cable (e.g., fibre ducts), or any material that forms the ground return path of the leakage current. This can result in unpredictably high dissipation factors.

3 Phase Unshielded Cables Enclosed in a Common Metallic Sheath

Each conductor of an unshielded three phase cable should be tested individually with the other conductors and the common sheath grounded. An overall test can be made with all conductors connected together and energized with the sheath grounded. See the Test Procedure Example below.

3 Phase Individually Shielded Cables

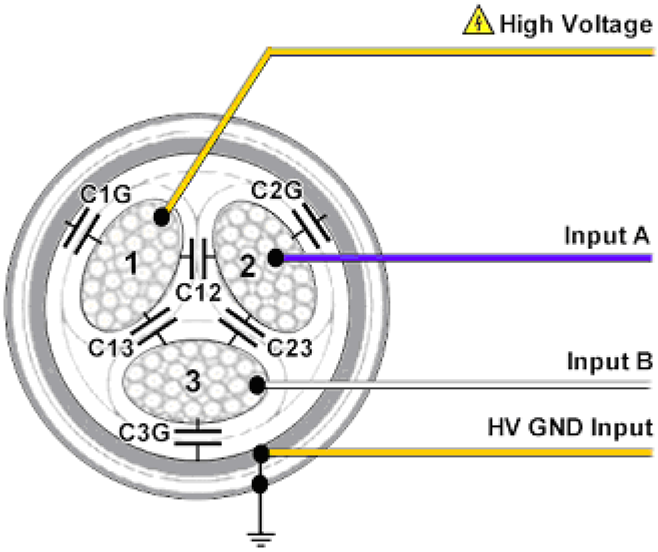
The same procedure as for single conductor shielded cable can be applied for this type of cable. Cable conductors not under test must be grounded. See also the Test Procedure Example below.

3 Phase Unshielded or Unsheathed Cables

In the case of a three phase unshielded cable a test procedure as outlined for a single-conductor unshielded cable can be performed. Supplementary it is possible, by an UST mode, to perform dissipation-factor measurements between two conductors, which are practically confined to the insulation between the two conductors.

20.4.2 Test Procedure Example

The figure and table below shows the specific connections with the corresponding test modes of a typical belted three-phase cable. It is assumed that no phase is left floating.



3 Phase Unshielded Cables Enclosed in a Common Metallic Sheath: Test connections to measure C_{1G}, C_{12} and C_{13}

Test Connections

DUT	INPUT A to	INPUT B to	INPUT HV GND to	Test Mode	High Voltage to
C_{1G}	2	3	GND shield	GST gA+B	1
C_{12}	2	3	GND shield	UST A	1
C_{13}	2	3	GND shield	UST B	1
C_{23}	1	3	GND shield	UST B	2
C_{2G}	1	3	GND shield	GST gA+B	2
C_{3G}	2	1	GND shield	GST gA+B	3
$C_{1G} + C_{2G} + C_{3G}$	-	-	GND shield	GST gA+B	1 + 2 + 3

Note: On 3 Phase Individually Shielded Cables only the capacitances C1G, C2G and C3G are measured in the same manner as described in the table above.

20.4.3 Measuring Data Interpretation

Temperature correction of the dissipation factors for cables is normally not made, since it requires a fairly close approximation of cable temperature, knowledge of the type of insulation and the date of its manufacture. Especially the temperature characteristics of the cable are normally not available and can therefore not be considered.

Evaluation of cable tests should be based on one or more of the following:

Comparison of power factors obtained for similar insulated cables obtained at time of test and under the same conditions.

Comparison with previous test results.

Comparison of results obtained from both ends.

Comparison with available manufacturer data.

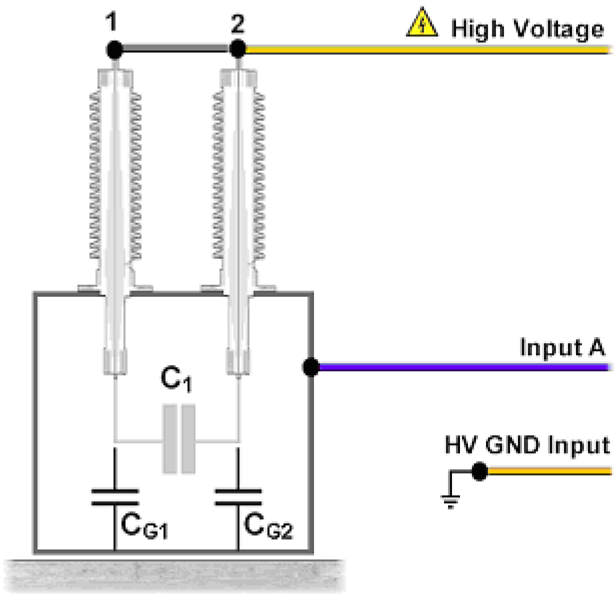
20.5 Capacitors

Capacitor test do check the insulation quality of the device. Normally the dissipation factor should be low and should stay stable as well as the capacitance. Units to be tested are power-factor correction capacitors (cap banks, used to improve the power factor of a high voltage grid), surge capacitors, energy storage capacitors, etc.

Capacitors can be built based on series of single cap modules (e.g. paper-oil coupling capacitor) If one modules shows a problem the result is always the average of all connected modules. So a small change in the measured total value could show a bigger problem in a single module.

Before any measurements are done it must be verified that the capacitor is completely discharged. Bushings and housing must be earthed.

Measurement Procedure



Measurement on an ungrounded two-bushing energy storage capacitor, connection for determination of $C_{G1} + C_{G2}$

C_1: main capacitor
C_{G1}, C_{G2}: earth insulation capacitance

Test Connections

DUT	High Voltage to	INPUT A to	HV GND to	Test Mode
C_1	1	2	GND	UST A
C_{G1}	1	2	Tank GND	GST gA+B
C_{G2}	2	1	Tank GND	GST gA+B
$C_{G1} + C_{G2}$	1 + 2	Tank	GND	UST A

20.6 Circuit Breakers

For insulation measuring purposes high voltage circuit breakers can be classified into two groups. Live tank breakers whose interrupting chamber is on HV potential and dead tank breakers whose interrupter chamber is accommodated in an earthed metal housing.

The applied test voltage for breakers should not exceed 10% to 25% above their rated operating line-to-ground voltage. That means in formula:

$U_{test} = [110\% .. 125\%] \times U_{rated}/\sqrt{3}$

As the internal AC power source of the MIDAS micro 2883 system can supply maximum 12kV, the insulation tests of breakers rated above 23.6kV are performed at 12kV.

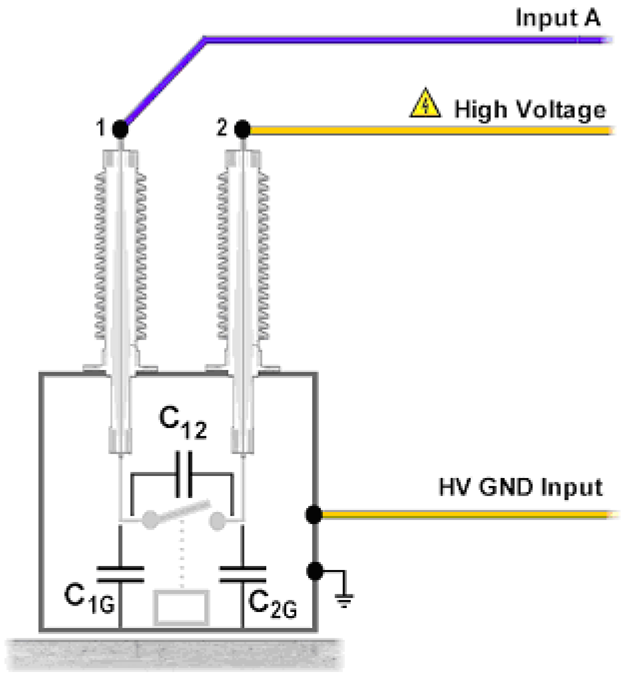
Depending on the nominal line voltage, operating mechanism (spring, hydraulic) and arc-quenching medium (air, oil, sulphur hexafluoride) circuit breakers are sometimes designed with two or more series connected interrupting chambers. For uniformly distributed voltage above the interrupting sections these breakers need grading capacitors across the interrupting chambers.

The following sections will give two examples of a procedure for testing circuit breakers. First a dead tank design is discussed and after the principle of testing a live tank CB with two interrupting chambers is shown.

For simpleness the examples below illustrate the testing procedure of one phase of switchgear. Although some designs have all three phases housed in a single tank, the test procedure and the analysis of the test results can be done on a per-phase basis.

20.6.1 Dead Tank Breaker

The test connections for a Dead Tank Breaker (e.g. ABB PASS type) is outlined below:



Dead Tank Breaker measurement connections for measurement of C_{2G} and C_{12}

C_{12}: contact insulation capacitance

C_{1G}, C_{2G}: earth insulation capacitance

Test Connections

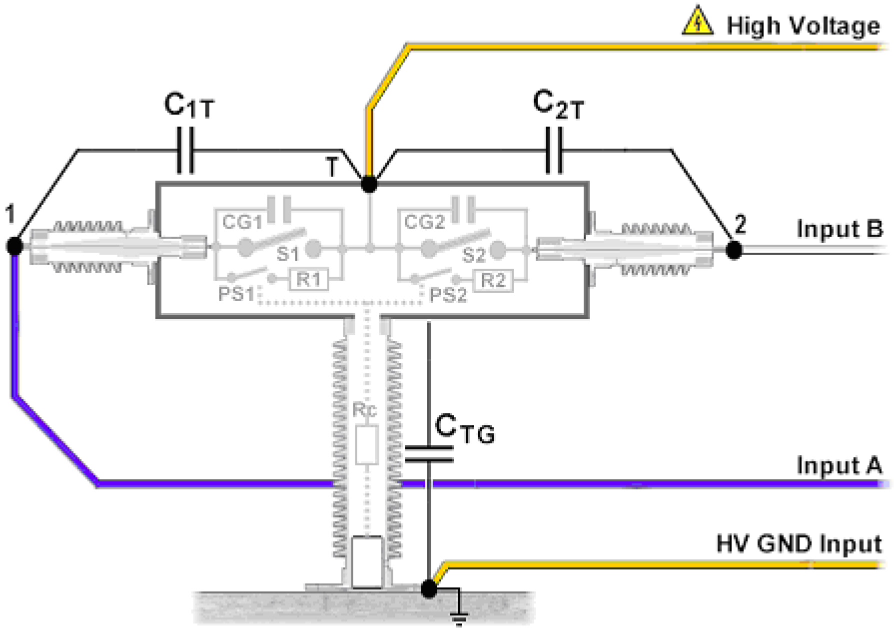
DUT	INPUT A to	INPUT HV GND to	Test Mode	High Voltage to	Breaker Status
C_{1G}	2	Tank GND	GST gA+B	1	open
C_{2G}	1	Tank GND	GST gA+B	2	open
C_{12}	1	Tank GND	UST A	2	open
C_{1G} + C_{2G}	-	Tank GND	GST gA+B	1 + 2	closed

Note: Test line #4 can be used to inter-check the measurement results. (#4 = #1 + #2). Additional measurements in other test modes can be executed to inter-check the measurements results.

Higher dissipation or power factor of GST gA+B could be the result of excessive moisture or by-products of arced SF_6 or oil, which have condensed or deposited on internal insulating members. In this case several make-break operations should be performed to verify that the result is reproducible.

20.6.2 Live Tank Breaker

The test procedure for a Live Tank Breaker (e.g. SIEMENS 3AP1 type) is shown below:



Live Tank Breaker measurement connections

$C_{1T} = C_{1B} + C_{G1} + (PS_1 + R_1)$

$C_{2T} = C_{2B} + C_{G2} + (PS_2 + R_2)$

C_{1B}, C_{2B}:	bushing stray capacitances (undrawn)
C_{G1}, C_{G2}:	grading capacitors
C_{TG}:	insulation column capacitance
S_1, S_2:	breaker switches
PS_1, PS_2:	pre insertion switches
R_1, R_2:	pre insertion resistors

Test Connections

DUT	INPUT A to	INPUT B to	INPUT HV GND to	Test Mode	High Voltage to	Breaker Status
C_{1T}	1	2	Floor GND	UST A	Tank (T)	open
C_{2T}	1	2	Floor GND	UST B	Tank (T)	open
C_{TG}	1	2	Floor GND	GST gA+B	Tank (T)	open
$C_{1G} + C_{2G}$	1	2	Floor GND	UST A+B	Tank (T)	open

Note: Test line #4 can be used to inter-check the measurement results. (#4 = #1 + #2). Additional measurements in other test modes can be executed to inter-check the measurements results.

Although pre insertion resistors and their switches are included in the sum capacitances of the interrupting chambers (C_{1T}, C_{2T}), the resistors R_1 and R_2 are normally very low resistive and the switches S_1 and S_2 have very low capacitance compared to the bushing and grading capacitors. Therefore the influences of these elements can be neglected.

Higher dissipation or power factor for the bushing/grading capacitor assemblies generally indicate a degradation or contamination of the grading capacitors. The measurement could also be influenced by surface leakage on the bushings. Abnormal capacitance values may be a sign of short-circuited sections of the grading capacitor assembly.

High losses along the insulation column may be caused by surface leakage or moisture, which may have condensed on internal tubes and rods.

20.6.3 Measuring Data Interpretation

The specific term “Tank-Loss Index (TLI)“ was introduced to assist in evaluating the results of the open and closed circuit breaker tests. The TLI index is defined as the real power difference of the measured open circuit and closed circuit for each phase. The open circuit real power value consists of the individual values measured on the two bushings of each phase. The index is calculated as follows:

TLI = (closed-breaker real power value) – (sum of two open-breaker real power values)

A TLI above 0.1W or below –0.2W may indicate a problem in the tank insulation medium, the drive rod or in other auxiliary insulations. In this case further investigations including SF_6/oil sample analysis or partial discharge measurements should be performed immediately

It is important to be aware, that circuit breakers can show complete different characteristics when they are not operated during a long period. Therefore if measurement results are in an unacceptable range, the breaker should be operated several times and the measurement should be performed once again.

If abnormal results are obtained, it is useful to investigate these values further by making a series of tests at several voltages. This can be used to determine if the condition causing the abnormal results is nonlinear or voltage sensitive.

Bushings with potential or dissipation factor taps may be tested separately. See also section “Applications Guide - Bushings”.

20.7 Surge (Lightning) Arresters

Surge arresters protect the electrical system by neutralizing discharge transient currents which are the result of lightning and switching.

The function of a surge arrester is similar to that of a circuit breaker. If a discharge transient current occurs it should close to eliminate the disturbance. After that it must reopen to prevent the flow of system power which would be destructive to it.

A complete test on a surge arrester involves impulse and over-voltage testing as well as a test for power loss at a specified test voltage using normal 50/60 Hz operating frequency. Impulse and over-voltage testing is generally not performed in the field since it involves a large amount of test equipment that is not easily transportable. Experience has demonstrated that the measurement of power loss is an effective method of evaluating the integrity of an arrester.

On the MIDAS micro 2883 power losses are automatically calculated and can be displayed by selecting the corresponding value “Real Power P”.

The surge arrester power loss test can reveal the presence of moisture, salt deposits, corrosion, cracked porcelain, open shunt resistors, defective pre-ionising elements and defective gaps.

Exercise extreme care when handling arresters suspected of being damaged, since dangerously high gas pressures can build up within a sealed unit. Everyone is instructed to stand clear during the testing of surge arrestors because of the possibility of their violent failure.

20.7.1 Test Levels

Surge arresters are built on a semiconductor or a metal oxide which have a non-linear volt-ampere characteristic. In order to permit meaningful comparisons between different units or older measurement results the test on surge arresters should always be performed at the same test voltage.

The following table gives an overview of recommended Test Levels for several surge arresters.

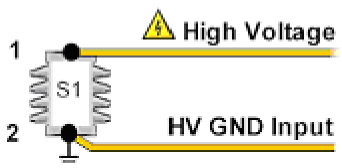
Arrester Type	Arrester Unit Rating [kV]	Test Voltage [kV]
Silicon Carbide	3.0	2.5
	4.5	4.0
	6.0	5.0
	7.5	7.0
	9.0 / 10.0	7.5
	12.0 and above	10
Metal Oxide	2.7 to 3.0	2.0
	4.5 to 12.0	2.5
	15.0 and higher	10.0

20.7.2 Test Procedures

Surge arresters can be equipped with leakage-current detectors or discharge counters. When testing such units the detector or counter should be short-circuited by applying a ground directly to the base of the arrester. The short-circuit must be removed before the arrester is returned to service.

Test Procedure on a Single-Unit Arrester

Arrester assemblies consisting of single units per phase can be tested by the grounded-specimen test method (GST). The line connected to the arrester is first de-energized and grounded, then disconnected from the arresters.

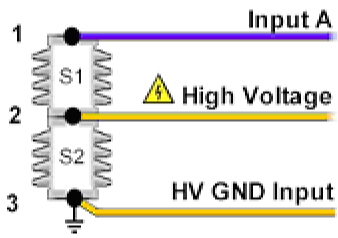


DUT	Test Mode	High Voltage to	INPUT A to	INPUT HV GND to	GND
S1	GSTg A+B	1	-	2	2

Single-unit arrester measurement

Test Procedure on a Double-Unit Arrester Stack

Assemblies consisting of two units per phase are tested in the manner outlined below. Again, the line is de-energized and grounded then disconnected from the arrester stack.

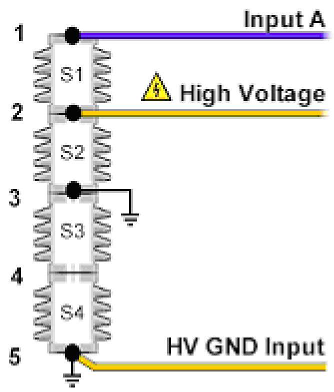


DUT	Test Mode	High Voltage to	INPUT A to	INPUT HV GND to	GND
S1	UST A	2	1	3	3
S2	GST gA+B	2	1	3	3

Double unit arrester stack measurement, connection for measurement of S1.

Test Procedure on a Multi-Unit Arrester Stack

Assemblies consisting of three units or more per phase are tested in the manner outlined in figure 53 on the next page. Again, the line is de-energized and grounded then disconnected from the arrester stack.



DUT	Test Mode	High Voltage to	INPUT A to	INPUT HV GND to	GND
S1	UST A	2	1	3 (or 5)	5 + 3
S2	GST gA+B	2	1	3 (or 5)	5 + 3
S3	GST gA+B	3	1	4 (or 5)	5 + 4
S4	GST gA+B	4	1	5	5

Multi unit arrester stack measurement, connection for measurement of S1.

20.7.3 Measuring Data Interpretation

Normally it is unnecessary to normalize the measurement result to a standard temperature since most types of surge arresters show only very little temperature dependence. Nevertheless if there is a substantial temperature influence it is useful to establish a temperature correction curve for each arrester design.

Surface leakage must be taken into account when power losses are measured. It can usually be minimized by wiping the porcelain with a plain, dry cloth. In some circumstances it might be necessary to use cleaning agents and waxes or to heat the porcelain surface.

Power loss values should be compared to older measurements or to similar units located under same conditions. If manufacturer data are available, they should be considered first.

Once a range of losses has been established, any deviation, either higher or lower, should be investigated. The following table points out the most important causes if abnormal losses are obtained and the surface leakage can be neglected.

Higher than Normal Losses

- Contamination by moisture and/or dirt or dust deposits on the inside surfaces of the porcelain housing, or on the outside surfaces of sealed-gap housings.
- Corroded gaps.
- Deposits of aluminium salts apparently caused by the interaction between moisture and products resulting from corona.
- Cracked porcelain.

Lower than Normal Losses

- Broken shunting resistors.
- Broken pre-ionising elements.

- Mistake in assembly.
- Poor contact and open circuits between elements