

# CDAX 605

## Capacitance & Dissipation Factor Test Set



# User Manual

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V01a

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## 1 Overview

### 1.1 General

CDAX605 is a measurement instrument that is used with a separate AC power source and a reference capacitor to form a complete measurement setup. It is a precision instrument using direct measurement for fast data acquisition in combination with an internal balancing circuit that secures a very high accuracy in line with traditional ratio-arm bridges. CDAX605 is designed for laboratory, production line or field testing of electrical equipment insulation and insulating materials as well as e.g. calibration of CCVTs and other ratio devices. A test set with unique high accuracy for the most demanding applications.

Testing can be performed at almost any voltage level pending on the rating of the equipment, the power source and the capacitor. The unit has full accuracy from current as low as 15  $\mu\text{A}$  and will accept a test current up to 5 A from the insulation under test. The test current may be increased by use of an external current transformer. CDAX605 is designed to be able to directly replace the (obsolete) Multi-Amp CB-605 High-voltage capacitance and dissipation factor bridge.

Traditional bridge methods can only measure and compare capacitive currents and since calibrated reference capacitors are typically available in the 100 to 1000 pF range, precision measurements on e.g. CCVTs and other devices with a high ratio may be difficult to perform. With the new technology in CDAX605, the input voltage to the device can be measured with a traditional reference capacitor while the secondary low voltage can be measured either with a second reference capacitor or with a reference resistor that is designed to give appropriate measurement current. Nor reference capacitors or resistors are included in a standard delivery.

### 1.2 Measurement principle

CDAX measuring system is based on the so called “double vector-meter method”. Measurement of the current  $I_N$  through a known standard capacitor  $C_N$  and current  $I_X$  through an unknown test object  $C_X$ . Both branches are energized by an external HV AC power source ( $U_{\text{Test}}$ ) and both currents are measured by high accuracy ammeters. Based on the data coming from the known standard capacitor all desired measuring values can be determined directly without any manual interaction.

The accuracy of the unit is based on “ammeter similarity”. If the ammeters are identically in all aspects, the inaccuracy of the system is zero. To ensure similarity during various operating conditions, an internal balancing circuitry can be activated to run automatically or on command. The results from the balancing check are if necessary used to adjust range gain settings to ensure that the two channels are similar over the measurement range.

## 2 Specification

The CDAX is intended for indoor use but can also be used outdoors but not in wet conditions (e.g. rain or high humidity, see Relative humidity below for more details). As accuracy of capacitance and ratio (not phase and dissipation factor) is affected by temperature, a stable environment regarding temperature is essential for accurate readings. To achieve maximum accuracy, turn on the unit and allow the unit to adjust to the ambient temperature for at least 30 minutes before first balancing. After balancing, specified accuracy will be achieved.

Parameter		Specification	Comment
General	Dimensions	335 x 300 x 99 mm (17.7" x 16.1" x 6.3")	Instrument
	Dimensions	520 x 430 x 220 mm (20.5" x 17.0" x 8.7")	Transport case
	Weight	4.4 kg (9.7 lbs)	Instrument only
	Mains voltage	100 - 240 V AC, 50/60 Hz	± 10 %
	Power consumption	60 VA (max)	
Measurement channels		2	2 physical ammeters
Measurement inputs		4	Reference, Input 1 (red), Input 2 (blue) and Ground
Test Modes		7	UST-R, UST-B, UST-RB, GST-GND, GSTg-R, GSTg-B, GSTg-RB
Test frequency		5 - 500 Hz	
Measurement range	Capacitance	> 0.01 pF	Max capacitance is a function of applied voltage
	Inductance, Lp	< 1 MH	Min inductance is a function of applied voltage
	Dissipation factor	0 - 100	0 - 10 within specified accuracy
	Voltage	Unlimited	Pending reference capacitor value only
	Current	15 µA - 5 A	Can be increased by using an external current transformer.
	Phase	0 - 360°/0-2π mrad	
	Accuracy (*)	Capacitance	± 0.02%
		± 0.1%	At reference and test currents 300-1000 mA
	Inductance	± 0.1 %	
	Voltage/current	± 0.5% of reading	Absolute voltage/current reading
	Dissipation factor	± (0.05% of reading + 2x10 <sup>-5</sup> )	At reference and test currents < 300mA
		± (0.05% of reading + 5x10 <sup>-5</sup> )	At reference and test currents 300-1000 mA
	Phase	± 0.02 mrad	At reference and test currents < 300mA
		± 0.05 mrad	At reference and test currents 300-1000 mA
	Voltage/current	± 0.5% of reading	Absolute voltage/current reading
Max resolution	Capacitance	0.001 pF	
	Inductance	0.1 mH	
	Dissipation factor	1x10 <sup>-6</sup>	
	Phase	1x10 <sup>-6</sup> Rad	
Measurement time		Selectable, default 5 s	
Warm-up time		30 min	
Temperature range	Operating	-20 - 55°C (-4 - 131°F)	
	Storage	-40 - 70°C (-40 - 158°F)	
Humidity	Operating	0 to 90% non-condensing	
Calibration		Absolute calibration and manual or automatic amplitude balancing	Recommended interval for absolute calibration is 1 year

SW	CDAX605 Control	Reference data entry Capacitance/inductance Resistance Dissipation factor Phase (Rad or min) Ratio measurements Data log/storage Data export (cut & paste)	Optional LabView and C# interface
	PC requirements	Pentium 500 MHz/512 Mb or better. Windows XP, Vista, 7 or 8	
	Communication	Ethernet (recommended) or USB	High quality shielded Ethernet cable or USB cable with ferrite choke
CE marking		LVD: IEC 61010 EMC: IEC 61326	

\*) Accuracy values are valid under the following conditions:

- Internal balancing performed after minimum 30 min warm-up
- Test generator frequency 50/60Hz
- THD of power source <10%
- UST measurement
- Measurement (averaging) time 5 s
- Ambient temperature  $23^{\circ} \text{C} \pm 5^{\circ}$
- Magnetic field at measurement frequency  $< 5 \mu\text{T}$

## 3 Safety

### 3.1 General



**IMPORTANT**

Read and comply with the following instructions.  
Always comply with local safety regulations.

### 3.2 Instrument symbols



Caution, refer to the accompanying documents, e.g. User Manual.



Protective conductor terminal.



Guard terminal used for GST measurements only. The terminal must be at ground potential and the symbol indicates that a hazardous live voltage must not be connected to the guard terminal.



WEEE, Waste Electrical and Electronic Equipment. Please utilize your local WEEE collection facilities in the disposition of this product and otherwise observe all applicable requirements.



CE marking indicates that the product fulfills all applicable EU requirements.



Marking indicates that the product fulfills the requirements in stated in CAN/CSA C22.2, No. 61010-1, 2<sup>nd</sup> edition including Amendment 1.

### **3.3 Warning and Caution Notices**

Warning and caution notices are used throughout this manual where applicable and should be strictly observed. These notices appear in the format shown below and are defined as follows:

#### **3.3.1 Warning**

Warning, as used in this manual, is defined as a condition or practice which could result in personal injury or loss of life.

#### **3.3.2 Caution**

Caution, as used in this manual, is defined as a condition or practice which could result in damage to or destruction of the equipment or apparatus under test.

### **3.4 General safety information**

The test set and the specimen to which it is connected are a possible source of high-voltage electrical energy and all persons making or assisting in tests must use all safety practice precautions to prevent contact with energized parts of the test equipment and related circuits.

Persons actually engaged in the test must stand clear of all parts of the complete high-voltage circuit, including all connections, unless the test set is de-energized and all parts of the test circuit are grounded. Persons not directly involved with the work must be kept away from test activities by suitable barriers, barricades, or warnings.

Treat all terminals of high-voltage power equipment as a potential electric shock hazard. There is always the potential of voltages being induced at these terminals because of proximity to energized high-voltage lines or equipment.

Always use a safety ground stick to ground the high-voltage conductor. Always disconnect test leads from power equipment before attempting to disconnect them from the test set. The ground connection must be the first made and the last removed. Any interruption of the grounding connection can create an electric shock hazard.

It is not possible to eliminate all potential hazards from, and in using, electrical test equipment. For this reason, every effort has been made to point out in this instruction manual the proper procedures and precautions to be followed by the user in operating this equipment and to mark the equipment itself with precautionary warnings where appropriate. It is not possible to foresee every hazard which may occur in the various applications of this equipment. It is therefore essential that the user, in addition to following the safety rules in this manual, also carefully consider all safety aspects of the test before proceeding.

High-voltage discharges and other sources of strong electric or magnetic fields may interfere with the proper functioning of heart pacemakers. Persons with heart pacemakers should obtain expert

advice on the possible risks before operating this equipment or being close to the equipment during operation.

### **3.5 Instrument safety**

This instrument 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. The voltage of the power source must be within the following rated operating voltage: 100-240 V  $\pm$  10 %, 50/60 Hz.

Before making connection to the power source, determine that the instrument rating matches the voltage of the power source and has a suitable two-pole, three-terminal grounding connector. The power input plug must be inserted only into a mating receptacle with a ground contact. Do not bypass the grounding connection. Any interruption of the grounding connection can create an electric shock hazard. Determine that the receptacle is properly wired before inserting the plug.

The test voltage which is reported by the instrument depends on the entered reference capacitance value. Also, during self-calibration, the instrument will not be indicating if high voltage is present. Never use the reported high voltage reading as an indicator whether high voltage is present. Always make sure that other safeguards exist so that the maximum allowable voltage cannot be exceeded due to incorrect readings from the instrument.

All persons making or assisting in tests must use all practical safety precautions to prevent contact with energized parts of the test equipment and related circuits. Also follow all local and company safety requirements. Persons actually engaged in the test must stand clear of all parts of the complete high-voltage circuit, including all connections, unless the test set is de-energized and all parts of the test circuit are grounded. Persons not directly involved with the work must be kept away from test activities by suitable barriers, barricades, or warnings.

- Safety is the responsibility of the user.
- Misuse of this high-voltage equipment can be extremely dangerous.
- The purpose of this equipment is limited to use as described in this manual. Do not use the equipment or its accessories with any device other than specifically described.
- Make sure that the instrument is properly grounded, both through its AC power cord and through the test ground connector.
- Never connect the test set to energized equipment.
- Before making any connections, make sure that the high voltage generator is de-energized and that all parts of the test circuit are properly grounded.
- Always disconnect test leads from test specimen before attempting to disconnect them at the test set.
- The ground connection on the test set must be the first made and the last removed. Any interruption of the grounding connection can create an electric shock hazard.
- Operation is prohibited in rain or snow.
- Do not use the test set in an explosive atmosphere.
- A qualified operator should be in attendance at all times while the test equipment is in operation.
- Observe all safety warnings marked on the equipment.
- Corrective maintenance must only be performed by qualified personnel who are familiar with the design and operation of the test set and the hazards involved.
- Refer to IEEE 510 - 1983, "IEEE Recommended Practices for Safety in High-Voltage and High-Power Testing," for information.

## 4 Maintenance

- DISCONNECT the MAINS plug before any cleaning or maintenance.
- Maintenance should be performed only by qualified personell familiar with the hazards involved with high-voltage test equipment.
- Read and understand Safety in the User Manual before performing any service.
- Routine maintenance is all that is required for these test sets. The cables and connector panel should be inspected frequently to be sure all connections are tight and all ground connections intact.
- The appearance of the test set can be maintained by occasional cleaning of the case, panel and cable assemblies. The outside of the carrying case can be cleaned with detergent and water. Dry with a clean, dry cloth. The control panel can be cleaned with a cloth dampened with detergent and water. Do not allow water to penetrate panel holes, because damage to components on the underside may result. A household all-purpose spray cleaner can be used to clean the panel. Polish with a soft, dry cloth, taking care not to scratch the display screen cover. The cables and mating panel receptacles can be cleaned with isopropyl or denatured alcohol applied with a clean cloth.

## 5 Warranty

### 5.1 Receiving Instructions

- Check the equipment received against the packing list to ensure that all materials are present. Notify Megger of any shortage.
- Examine the instrument for damage received in transit. If damage is discovered, file a claim with the carrier at once and notify Megger, giving a detailed description of the damage.
- This instrument has been thoroughly tested and inspected to meet rigid specifications before being shipped. It is ready for use when set up as indicated in this user manual.

### 5.2 Warranty

- Products supplied by Megger are warranted against defects in material and workmanship for a period of one year following shipment.
- Our liability is specifically limited to replacing or repairing, at our option, defective equipment.
- This warranty does not include batteries, lamps or other expendable items, where the original manufacturer's warranty shall apply.
- We make no other warranty. The warranty is void in the event of negligence abuse (failure to follow recommended operating procedures) or failure by the customer to perform specific maintenance as indicated in this manual.

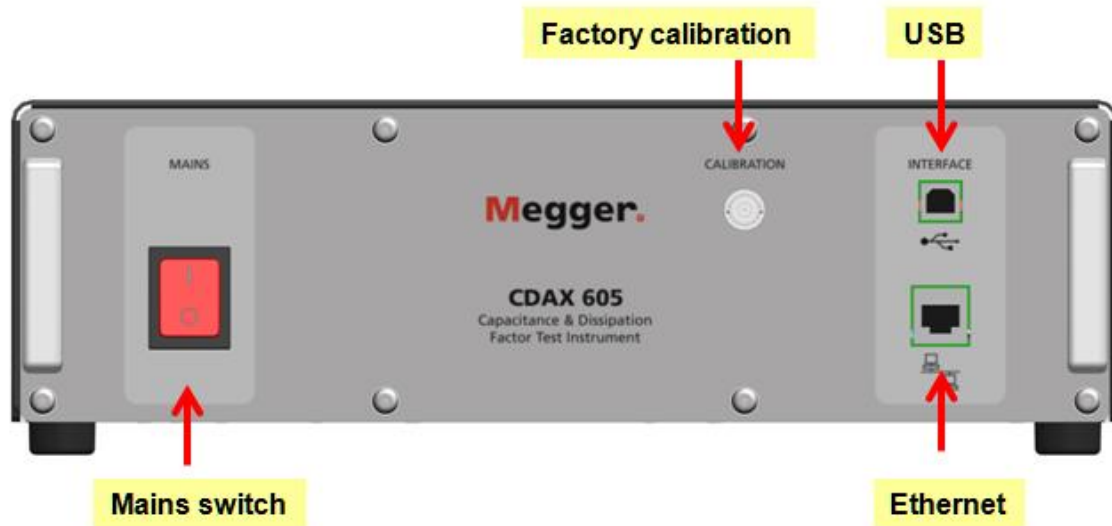
### 5.3 Warranty repair

- Equipment returned to the factory for repair must be shipped prepaid and insured.
- Contact your Megger representative for instructions and a return authorization (RA) number.
- Please indicate all pertinent information, including problem symptoms.
- Also specify the serial number and the catalog number of the unit.



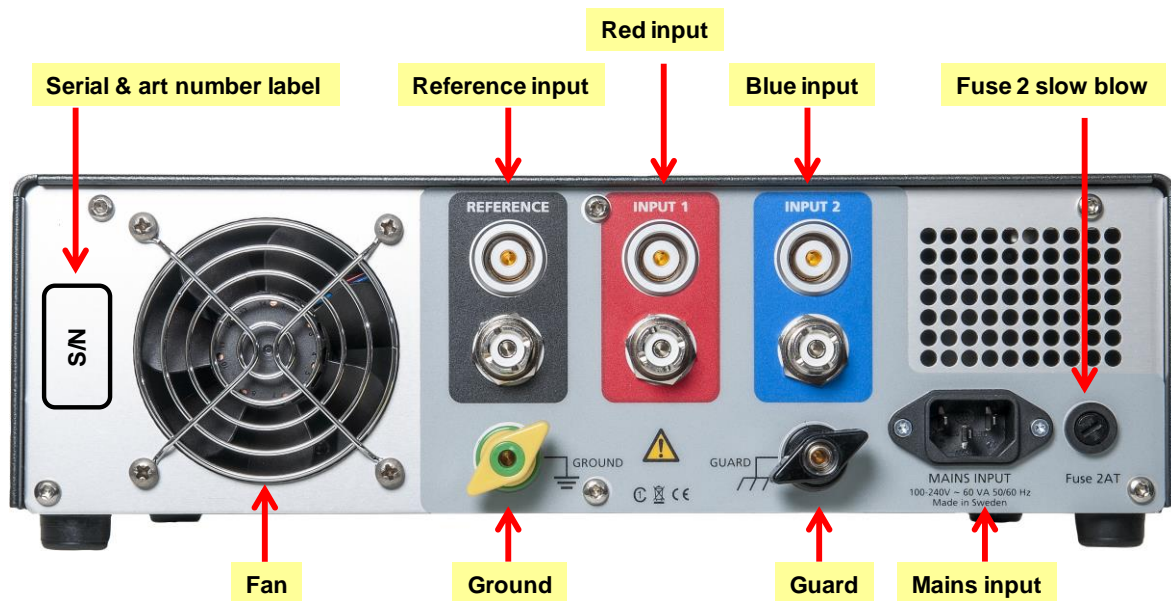
## 6 Control, indicators and connectors

### 6.1 Front panel



On/off	Mains switch, single pole switch, On = right, Off = left, see symbol on panel
Calibration	Used for factory calibration only
USB/B	Controlling the CDAX from a PC using USB (USB cable with ferrite choke)
Ethernet	Controlling the CDAX from a PC or using Ethernet (shielded Ethernet cable) Ethernet communication is recommended due to better protection against high interference.

### 6.2 Back panel



Label	Article number (AI-19070) and serial number (YYXxxxx)
Reference	Input for reference (normal) capacitor, Lemo and UHF connectors in parallel
Input 1	Red input, Lemo and UHF connectors in parallel
Input 2	Blue input, Lemo and UHF connectors in parallel
Input adapter	Three UHF to BNC adapters are delivered as a standard accessory making it possible to use BNC cables instead of UHF.
Mains input	100-240 V AC, 50/60 Hz, max 60 VA, disconnecting device
Fuse	2AT slow blow 5x20 mm fuse, Littlefuse or similar
Ground	Connector for attaching CDAX to protective ground
Guard	Connector for attaching CDAX to guard when doing GST measurements A jumper is delivered with the unit between Ground and Guard. Note: If a jumper is connected between ground and guard, it must be removed when performing GST measurements!

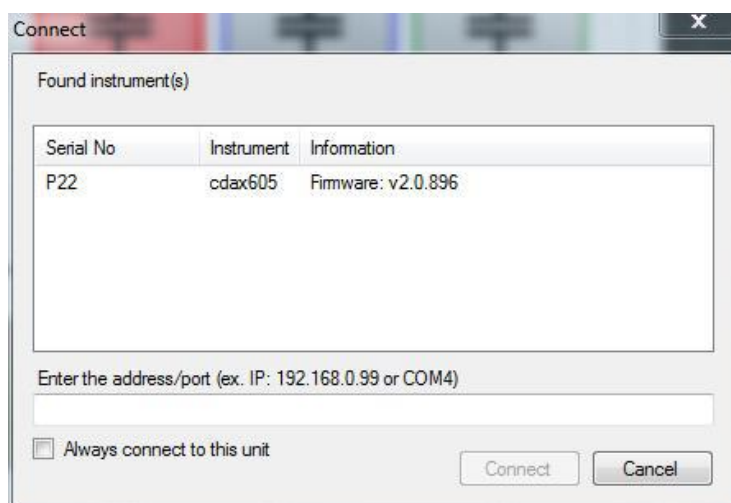
## 7 Software Installation

To start installing the software, insert the USB memory stick and run the program CDAX 605 install program. Follow instructions on the screen.

## 8 CDAX605 Control

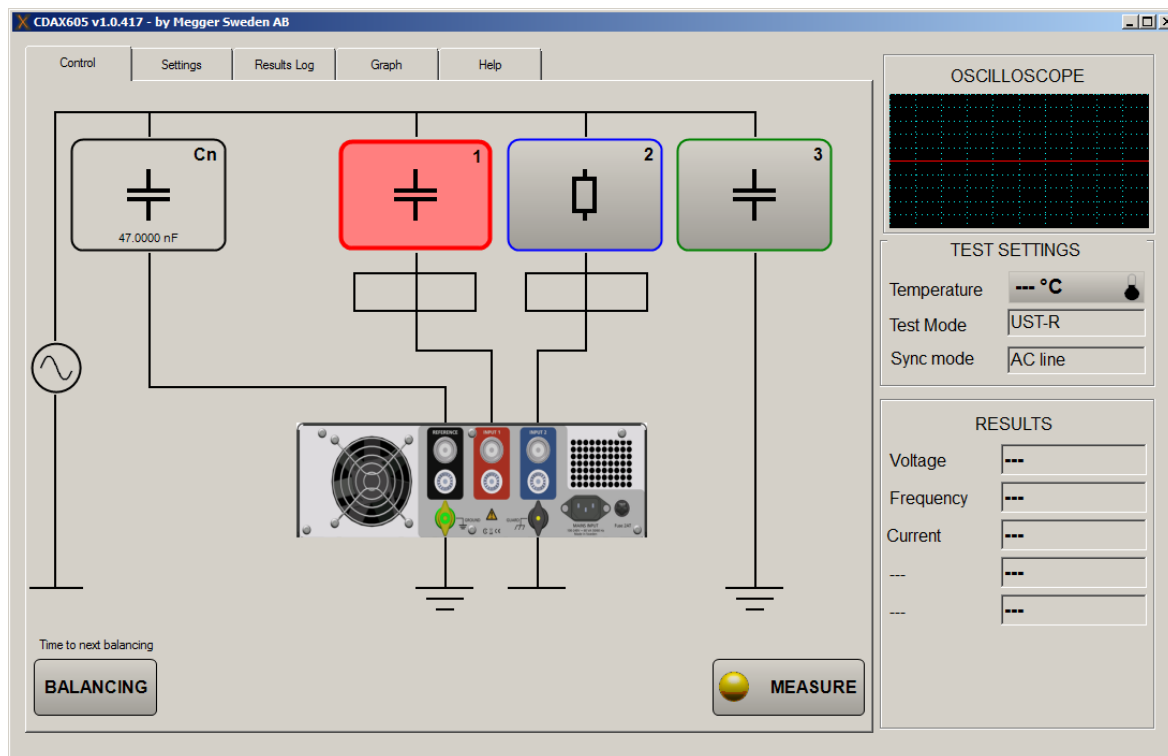
### 8.1 Connect

Connect the PC to CDAX using the Ethernet cable. When you start the CDAX605 software it will try to connect to a CDAX605 unit. When the dialog is displayed you can select which CDAX605 unit you want to connect to. You can either select it in the list of found instruments or enter the IP address. You may also select to always try to connect to that specific unit.



It is possible to communicate between CDAX and the PC using USB, but this is mainly used while updating software in an office environment.

### 8.2 Control tab

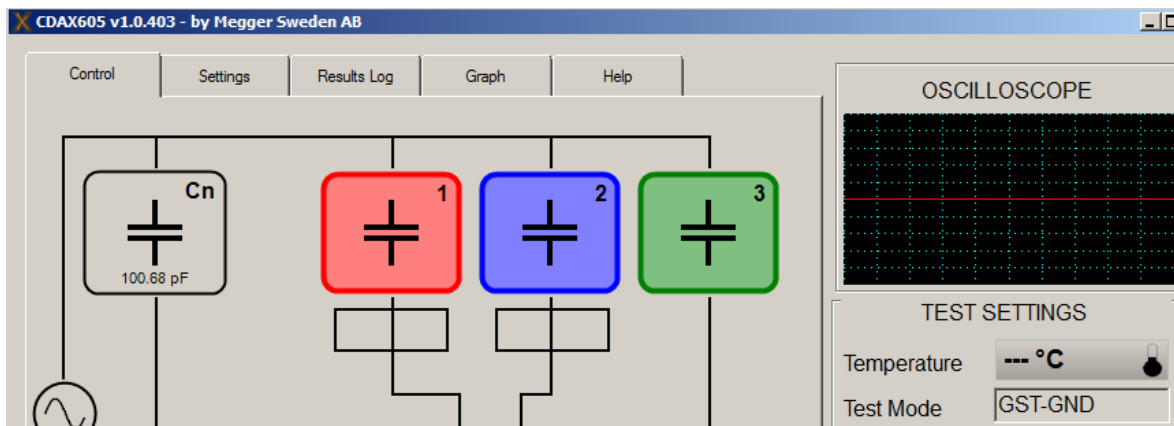


The main screen tab is the tab shown at start-up and the screen used for measuring.

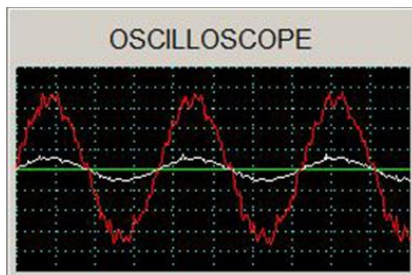
By activating one or several buttons/measurement channels 1, 2, 3 the instrument is put in the different standard test modes. CDAX supports the following test modes:

<b>UST: Ungrounded Specimen Testing</b>			
Test mode	Measure	Ground	Guard
UST-R	Red	Blue	---
UST-B	Blue	Red	---
UST-RB	Red and Blue	---	---
<b>GST: Grounded Specimen Testing</b>			
Test mode	Measure	Ground	Guard
GST-GND	Ground	Red and Blue	---
GSTg-R	Ground	Blue	Red
GSTg-B	Ground	Red	Blue
GSTg-RB	Ground	---	Red and Blue

As an example, activating all channels puts the instrument in GST-GND mode.



Continuous measurements are shown in the “Results” part

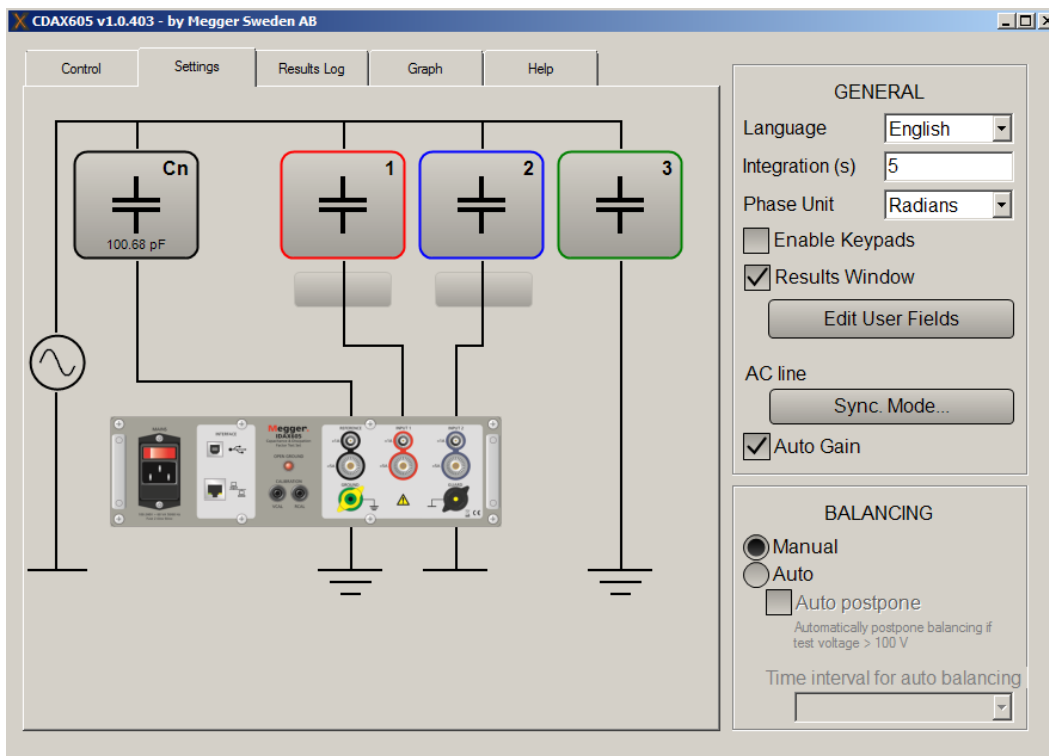


The Oscilloscope displays the signal (white) proportional to current in reference (Cn) arm and the signal (red) proportional to the measured current (red), e.g. in Cx1-arm. Since the “ampere-meters” have 4 gain steps, the proportional constant varies in steps increasing the currents. The oscilloscope time base is automatic

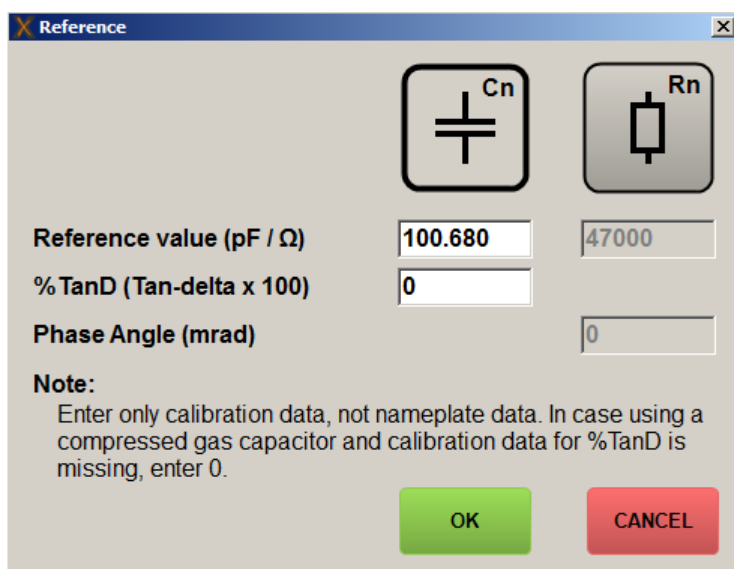
To start an individual measurement press “Measure”

To manually start a balancing check press “Balancing”

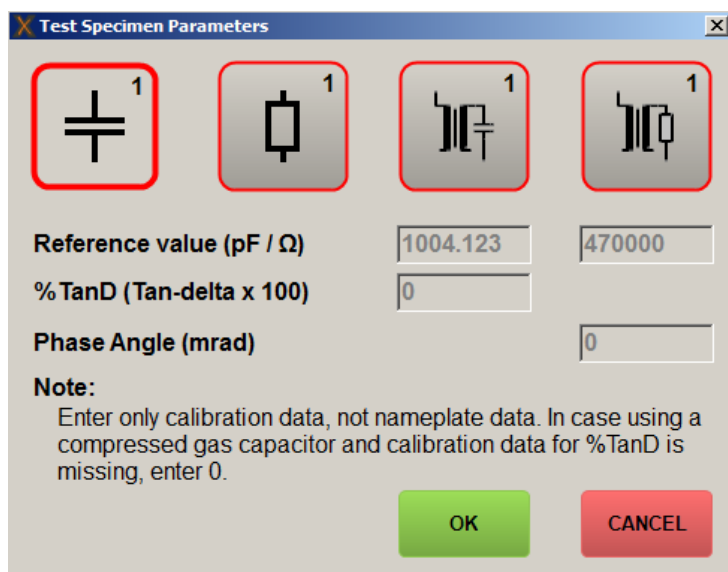
### 8.3 Settings tab



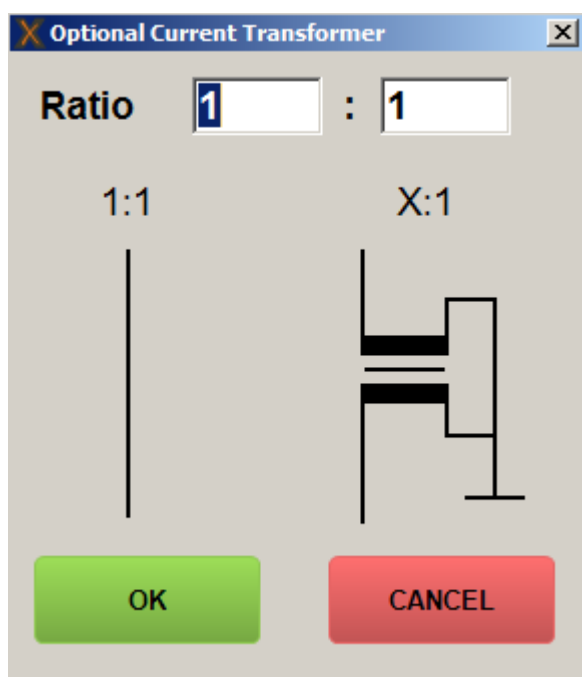
Clicking on the reference brings up the reference dialog where you can change the type and value; Typically, a zero dissipation factor is used for compressed gas filled reference capacitor, but it is possible to add a dissipation factor of the reference capacitor if e.g. a reference polystyrene capacitor is used. Note that accuracy of measurement, and possible temperature dependence, depends very much of type of reference and most accurate results are achieved by use of standard compressed gas capacitor.



Clicking on one of the test specimens makes it possible to change its settings.

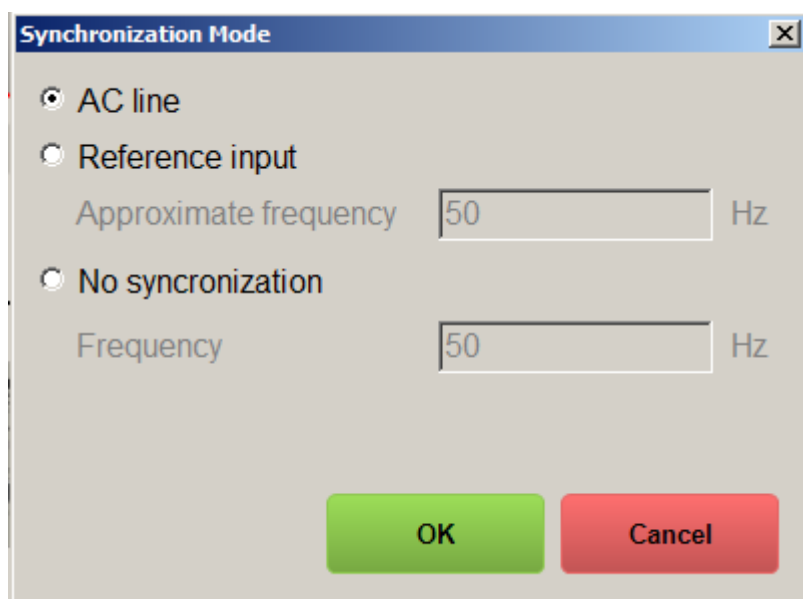


Clicking one of the squares on the red/blue connection “leads” brings up the options for using an external current transformer.



Synchronization mode:

CDAX measures fundamental frequency of reference, Cn, current and sample current using a filter with a bandwidth of  $\pm 6$  Hz/s of integration. E.g. using 5 s of integration, the bandwidth is  $\pm 1.2$  Hz. CDAX supports three synchronization modes that are selected by press the “Sync. Mode...-button”.



- AC line means that the mains frequency of the CDAX unit is measured continuously and the frequency is used as synchronization frequency. This is the best choice when the unit is used with a test generator supplied from the AC mains.
- Reference input means that the reference input signal is measured and used for synchronization. You need to set an approximate synchronization frequency (e.g. 50, 60 or 400 Hz). Note: Reference current must be > 30  $\mu$ A for synchronization
- No synchronization means that the CDAX system measures using set frequency for synchronization regardless of AC line frequency or applied frequency on reference input. You must set a frequency near the actual frequency.

In most measurement setups, CDAX is measuring a capacitive object and using a standard capacitor on the reference input. In those situations, “No synchronization” works well and gives fast updates of displayed results.

However when measuring a mixed setup, e.g. ratio with a standard capacitor as reference and a reference resistor on secondary, the frequency is of utmost importance for accuracy in ratio values and synchronized mode must be used.

## 9 Calibration

### 9.1 Warm-up

To achieve maximum accuracy, turn on the unit and allow the unit to adjust to the ambient temperature for at least 30 minutes and a balancing is performed.

### 9.2 Calibration procedure

System calibration is made up of two routines: Calibration, typically performed every year, and manual or automatic amplitude balancing, performed in the field after warm-up and at customer defined intervals.

The calibration for amplitude and phase should be performed at the recommended calibration interval of the system, i.e. every year. Amplitude balancing is performed when asked for or automatically by the instrument at intervals specified by the user. During amplitude balancing the



instrument checks that (and if necessary adjust for) the two measuring channels, reference and specimen input, are similar.

The balancing procedure is controlling the accuracy of relational measurements such as capacitance and ratio. Calibration is confirming phase and dissipation factor measurements as well as absolute readings of the two measurement channels, i.e. voltage and current readings.

### 9.2.1 Calibration

Calibration is performed using the MIX utility software. The required hardware for performing a complete absolute calibration is, apart from the system itself, a calibrated Digital Multi Meter (DMM) with adequate accuracy. The procedure is fully documented in the MIX utility software. A few points are however worthwhile to note:

- It is convenient to store the calibration data also outside of the instrument for future reference.
- For highest accuracy, make sure that the instrument is calibrated in its intended operating conditions.
- As pointed out in the MIX software: When measuring the resistance of the internal reference resistor – Make sure that the excitation current of the DMM is not greater than 100  $\mu$ A. This is checked referring to the DMM user manual.

### 9.2.2 Balancing

Amplitude balancing is by default performed automatically after 30 minutes of warm-up (this can be cancelled if e.g. the instrument is just re-started from a previous session and already warmed-up). After the initial balancing, the instrument will re-check the channels manually when called for or automatically at specified intervals. This is configurable in the CDAX Control settings tab. The balancing parameters are stored in the instrument. It is also possible to configure the instrument to defer automatic balancing if the high voltage is measured to be active.

## 10 Operating instructions

### 10.1 Standard test circuits

In this chapter the standard measuring setups are explained. The circuits are also applicable for inductances.

#### 10.1.1 Ungrounded Specimen Test (UST) with grounded HV Supply

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 voltage and current transformers, this configuration determines the capacitance and dissipation factor between the various winding groups.

In this mode the highest measurement accuracy is reached.

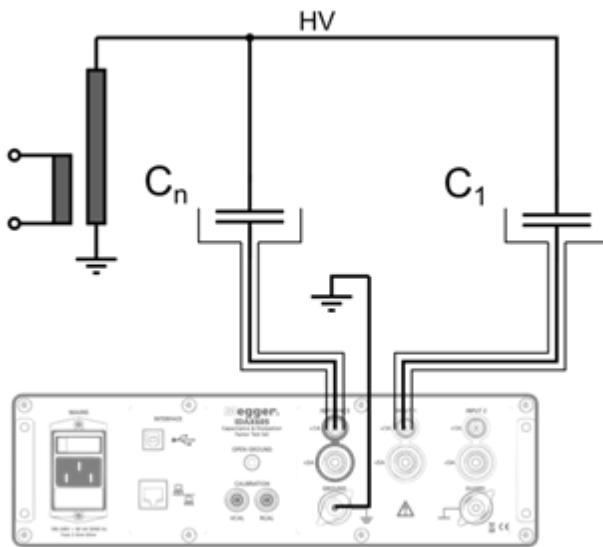
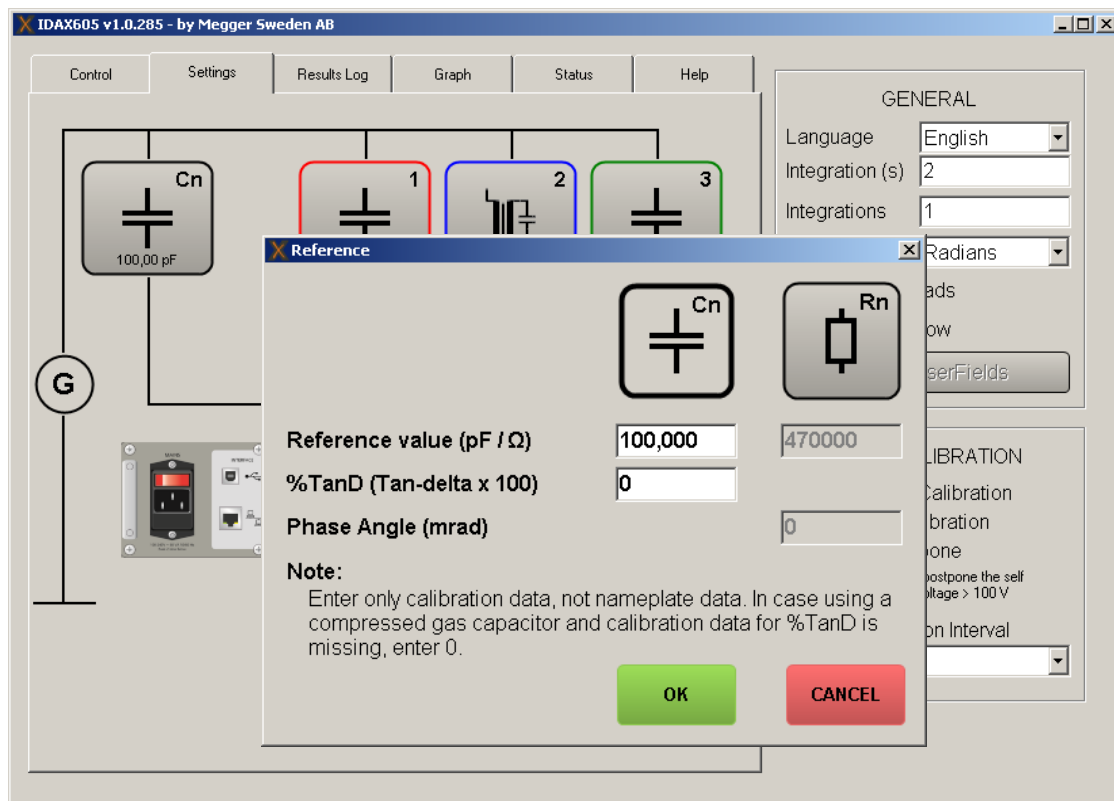


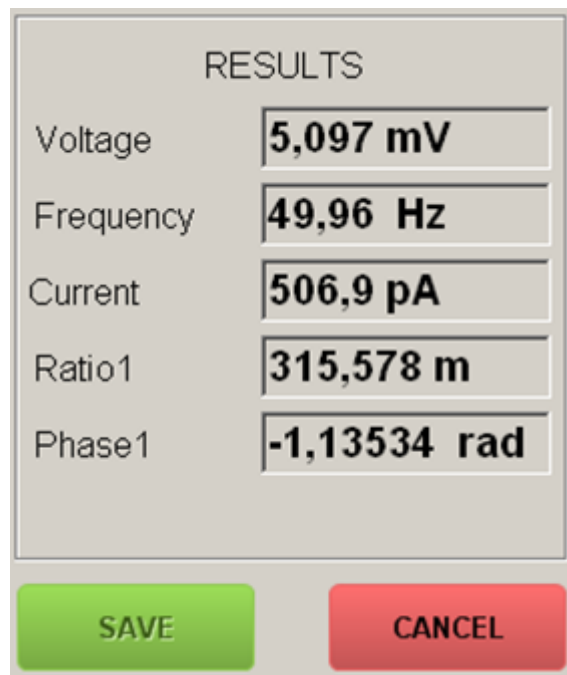
Figure 1. Capacitance measurement setup

#### 10.1.1.1 Step-by-step instructions

- Before connecting the instrument, make sure that the high voltage generator is de-energized and that all parts of the test circuit are properly grounded.
- Referring to Figure 1, connect the instrument to:
  - Test ground, i.e. same grounding point as the test specimen.
  - A suitable AC power source.
  - The reference capacitor,  $C_n$ .
  - The test specimen.
- Set up the computer:
  - Connect the computer to the CDAX605 using a shielded Ethernet cable (or USB cable with ferrite choke).
  - Run CDAX605 Control and connect to the instrument.
  - In the Settings tab, set the value of the reference capacitor (see figure below) and also configure the test specimen (press red, and/or blue, green).



- Return to Control tab
- Commence the measurement procedure:
  - Remove the high voltage side safety grounding.
  - Carefully raise test voltage somewhat and check that the voltage reported by the instrument is as expected. Note that incorrect input of the reference capacitance value will lead to incorrectly reported voltage level, which may lead to excessive voltage levels.
  - Check that the continuously updated measurement results are as expected.
  - Raise voltage to the specified test level.
  - Press MEASURE. Results will be displayed

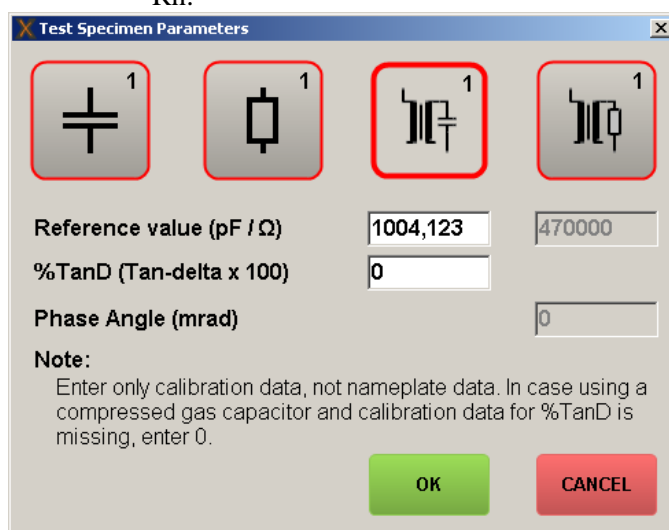


- Save, results will be stored in “results log”. If “cancel”, results are not stored
  - Perform additional measurements as required by pressing MEASURE again.
  - Lower the test voltage and turn of the generator.
- Disconnect the instrument in reverse order as during connection, i.e. de-energize and ground all parts of the circuit before disconnecting.

### 10.1.2 Ratio transformer with grounded HV supply

Calibrate/confirm the two reference components Cn and Cn1 (labeled C1 in Figure 1) by connecting them as in Figure 1 (section 10.1.1) and following the corresponding instruction. Note that the voltage handling capability of Cn1 might be limited.

- Without reconnecting:
  - Set up the software for ratio measurement, entering the calibrated values for Cn or Rn.



- Measure the ratio and verify that it is exactly unity with zero phase shift.

- De-energize the high voltage generator and ground the setup.
- Connect the ratio transformer as in Figure 2.

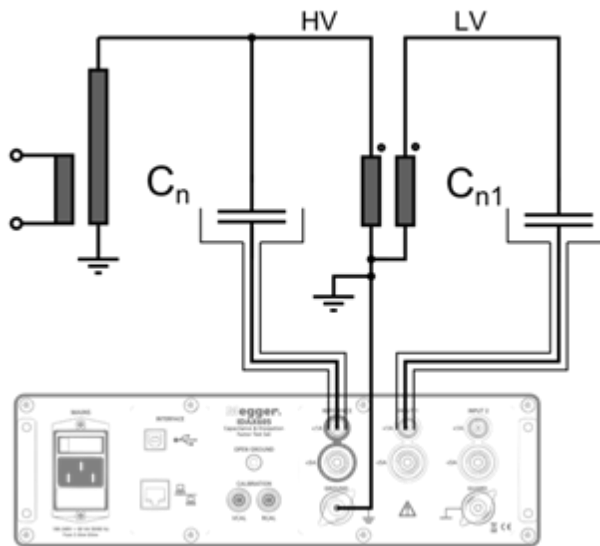


Figure 2. Ratio measurement setup

- Commence the measurement procedure:
  - Remove the high voltage side safety grounding.
  - Carefully raise test voltage somewhat and check that the voltage reported by the instrument is as expected. Note that incorrect input of the reference capacitance value will lead to incorrectly reported voltage level, which may lead to excessive voltage levels.
  - Check that the continuously updated measurement results are as expected.
  - Raise voltage to the specified test level.
  - Press MEASURE. Results will be displayed
  - Perform additional measurements as required by pressing MEASURE again.
  - Lower the test voltage and turn of the generator.

Ratio is calculated by the software using the current into the reference input,  $I_n$ , the current into the specimen input,  $I_x$ , and the values of  $C_n$  and  $C_{n1}$  according to the following formula:

$$N = \frac{I_n}{I_x} \cdot \frac{C_{n1}}{C_n}$$

### 10.1.3 Grounded Specimen Test (GST) with floating HV Supply

This test mode enables the measurement of capacitances that are normally grounded 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.

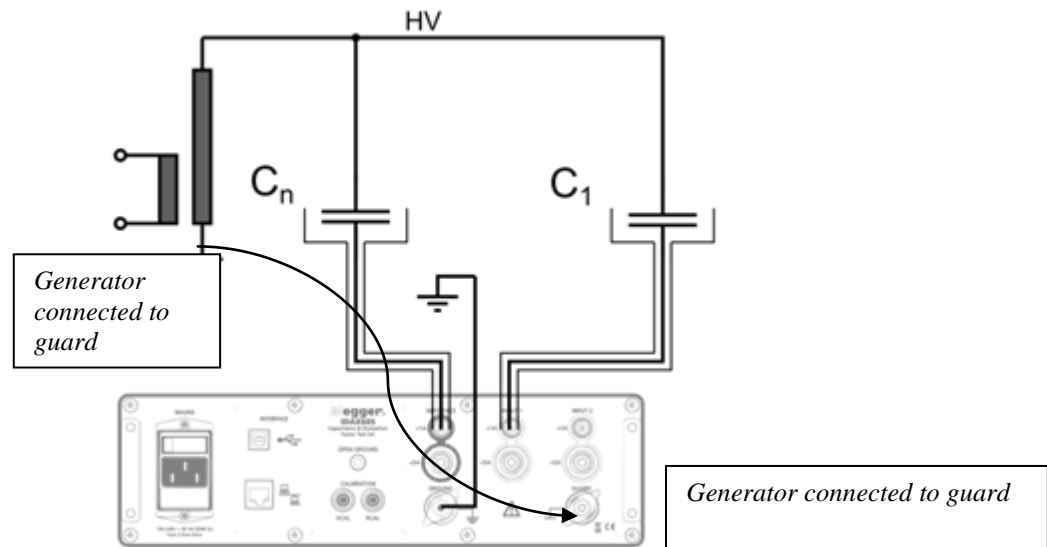


Figure 3. Standard GST test circuit

Note: If a jumper is connected between ground and guard, it must be removed when performing GST measurements!

In the GST mode the inter-winding capacitance of the HV source will be added to the measurement and need to be as small as possible. Special double-shielded HV sources can be used to minimize this influence.

## 10.2 Measurements with Test Current greater than 5A (with external current transformer)

### 10.2.1 General information on Range Extension

When measuring large test object capacitances, the test current may exceed the maximum permissible input current of CDAX (5A) and an external current transformer (current comparator) must be used for range extension.

When using an external CT for range extension, the accuracy of CDAX will be reduced by the inaccuracy of the CT. In addition, additional errors may occur depending upon the test mode applied.

### 10.2.2 Errors caused by an external CT

#### 10.2.2.1 Correction formulas for $\tan \delta$ and capacitance

##### 10.2.2.1.1 Influence of the CT ratio accuracy

The ratio error mainly influences the capacitance measurement and the correction is performed according to the following formula:

$$C_{\text{corr}} = C_{\text{meas}} * (1 + \text{ratio error (\%)} / 100)$$

The polarity of the current inaccuracy must be considered.

##### 10.2.2.1.2 Influence of the CT phase accuracy

The error angle influences the dissipation factor measurement and the effective measured value of dissipation factor  $\tan\delta$  is calculated according to the following formula:

$$\tan\delta_{\text{corr}} = \tan\delta_{\text{meas}} + \text{phase accuracy (minutes)}/3440$$

Example:

A conventional current transformer (comparator) of Class 0.1 has the following accuracy:

Phase accuracy:  $\pm 1$  Minute

Ratio error:  $\pm 0,1\%$

Measured values:  $C_x = 100\text{nF}$ ,  $\tan \delta = 1\text{e-}3$

From the formulas given above, capacitance reading should be corrected by 0.1% and  $\tan \delta$  by  $3\text{e-}4$ .

## 11 Stored data and reporting

Results are always stored by date and time in \*.txt log files (default in directory My documents\CDAX605 ). A new log file is created every time the SW is started.

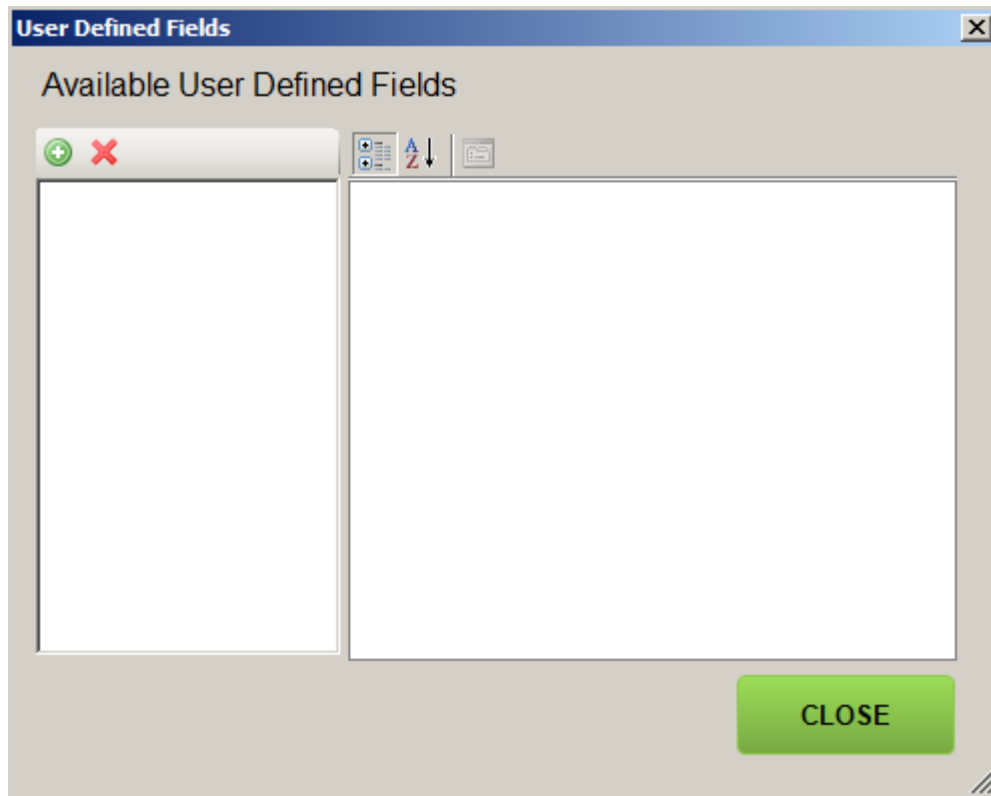
Results can also be stored by using the “Export” function in the results log tab. Measurement data as displayed in the table will be stored as a \*.csv file in the selected directory. “Clear” is deleting data from the table for e.g. starting a new measurement session to be exported as a new file. Note: “Clear” will only clear the displayed data and not delete any data from the log file.

Reporting can be done in e.g. Excel by opening/importing exported data, importing a log file or by cut-and-paste data directly from the results log table.

## 12 User fields

User fields present a way for the user to customize the measurement results of the CDAX605 software. By defining statistical constraints on a measured parameter as defined by a user field, the risk of taking bad measurements due to measurement noise or drift lessens. In order to use user fields, the Results Window checkbox in the settings tab has to be checked. A measurement dialog will then popup each time the user presses the MEASURE button.

## 12.1 Editing user fields



### 12.1.1 Description of buttons



#### **Add user field**

This button adds a new user field to the list. The field is given the default name of “Unnamed”.



#### **Remove user field**

This button removes the selected user field.

### 12.1.2 User field parameters

When selecting a user field, one will be shown a list of its parameters. The following picture shows the parameters of a user field called “Correction factor”:



<input type="checkbox"/> <b>Misc</b>	
AppendToLog	<b>True</b>
EnableRequirements	<b>True</b>
Format	<b>F5</b>
Formula	<b>result1_value/nomrat</b>
Input	False
Name	<b>Correction factor</b>
<input type="checkbox"/> Requirements	
Capacitance	False
RatioTransformerCapacitance	<b>True</b>
RatioTransformerResistance	<b>True</b>
Resistance	False
SignificantDigits	4
<input type="checkbox"/> <b>Statistics</b>	
DataCount	<b>5</b>
Slope	0
StandardDeviation	0
TimeoutSeconds	<b>0</b>
Unit	
Value	<b>1,00062</b>
Variable	

Listed below are the User Field parameters.

Parameter name	Value	Description
AppendToLog	<b>True/False</b>	<b>True</b> if user field should be included in the log
EnableRequirements	<b>True/False</b>	<b>True</b> if the parameter should only be shown if specified <b>Requirements</b> are met.
Format	See <a href="http://en.csharp-online.net/CSharp_Format_Specifiers">http://en.csharp-online.net/CSharp_Format_Specifiers</a>	Specifies how the numerical result should be presented, i.e. number of decimals etc. If this parameter is left empty the format will be specified instead by <b>SignificantDigits</b> , see below!
Formula	Valid mathematical expression, see separate section below.	States the formula to use in order to calculate the sought result.
Input	<b>True/False</b>	If <b>True</b> the user is prompted for the value during the measurement and it is treated as an input variable instead. An example could be Nominal ratio.
Name	Text string	The name of the User Field.
Requirements/Capacitance	<b>True/False</b>	If <b>True</b> this user field is only shown during measurement of capacitive type specimens
Requirements/RatioTransformerCapacitance	<b>True/False</b>	If <b>True</b> this user field is only shown during measurement of ratio and if using a capacitive reference component on the secondary
Requirements/RatioTransformerResistance	<b>True/False</b>	If <b>True</b> this user field is only shown during measurement of ratio and if using a resistive reference component on the secondary
Requirements/Resistance	<b>True/False</b>	If <b>True</b> this user field is only shown during measurement of resistive type specimens
SignificantDigits	Positive integer larger than zero.	The number of significant digits to show. Only used if <b>Format</b> is left blank.
Statistics/DataCount	Non-negative integer.	Minimum number of data points required.
Statistics/Slope	Positive numerical value or zero.	The maximum allowed "slope" of the collected data points. Not valid for single data point measurements. Slope is defined as

		$r = \frac{\sum x_i y_i - \frac{\sum x_i \sum y_i}{n}}{\sqrt{\left(\sum x_i^2 - \frac{(\sum x_i)^2}{n}\right) \left(\sum y_i^2 - \frac{(\sum y_i)^2}{n}\right)}}$ <p>, where r is the slope, <math>x_i</math> are the data points and <math>y_i</math> are the corresponding sequence number, i.e. 1,2,3,4 ... n is the number of measurements</p>
Statistics/StandardDeviation	Positive numerical value or zero.	The maximum allowed standard deviation of the measured data.
Statistics/TimeoutSeconds	Positive numerical value or zero.	The maximum allowed time to collect measurement data points before timing out.
Unit	Character string.	The unit which to append the result.
Value	-	The immediate value of the user field, do not edit.
Variable	Either a valid variable name (containing the characters [a-z], [A-Z], [0-9] and '_') or left empty.	The variable name to use if the <b>Input</b> parameter is <b>True</b> .

### 12.1.3 Entering a formula

The formula can contain all standard operators: +, -, \*, /, ^.

Predefined constants are:

- The eulerian number with: **e = 2.718281828459045235360287**
- Pi with **pi = 3.141592653589793238462643**
- The imaginary unit with: **i = sqrt(-1)**

The following postfix operators can be used: {n}, {mu}, {m}, {k}, {G}, {M}.

Standard functions: **abs, sin, cos, tan, sinh, cosh, tanh, ln, log, log10, exp, sqrt**


Complex functions: **real, imag, conj, arg, norm**

Predefined variables are:


Variable name	Description
freq	frequency
hv_u	high side voltage
amxr_shunt	gain setting of reference input
amxx_shunt	gain setting of specimen input
amxr_i	input current into reference input
amxx_i	input current into specimen input
amxr_u	reference current amplifier output
amxx_u	specimen current amplifier output
amxg_uin	voltage from guard to ground
amxr_uin	voltage from guard to reference input
amxx_uin	voltage from guard to specimen input
result1_value	primary result, i.e. capacitance for capacitance measurements, resistance for resistance measurements or ratio for ratio measurements.
result2_value	secondary result. It is always equal to loss angle for capacitance measurements, impedance phase angle for resistance measurements and phase shift for ratio measurements. All angles are in radians.

#### 12.1.4 Example – Creating a user field showing correction factor

First we need to prompt the user for the nominal ratio (which is not known by the software).

- Press the  button.
- Edit the Name parameter of the field so that it reads “Nominal ratio”.
- Remove the contents of the “Formula” parameter.
- Set AppendToLog to True.
- Set Input to True so that the user will be prompted to enter the value.
- Set the parameter “Variable” to “nomrat”. This is the new variable name of the nominal ratio.

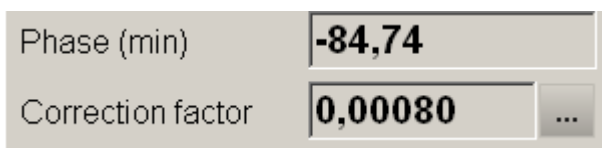
Now we need to add the actual user field which shows correction factor.


- Press the  button.
- Edit the Name parameter of the field so that it reads “Correction factor”.
- Edit the contents of the “Formula” parameter so that it reads “result1\_value/nomrat”. This is how the correction factor is calculated. “result1\_value” corresponds to the primary measurement result, in this case the ratio.
- Set the Format parameter to “F5”. This means fixed precision presentation with 5 digits after the decimal separator.
- Set AppendToLog to True.
- Set EnableRequirements to True.
- Under Requirements, set the parameters RatioTransformerCapacitance and RatioTransformerResistance to True. The rest of the requirement parameters should be False. This is so that the result shall only show up when measuring ratio and not, for example, capacitance.
- Under Statistics, set the DataCount parameter to 5 in order to make the instrument calculate the mean result from 5 consecutive measurements.


Now we are done. Press CLOSE. Check the Results Window checkbox in the settings tab in order to test the new user fields. Perform a ratio measurement and check that it works.

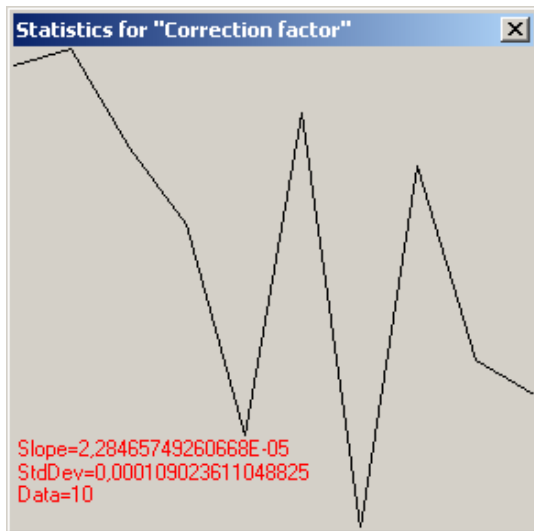
### 12.2 The Results Window

- The Results Window pops up when the user presses MEASURE, if the checkbox “Results Window” is checked in the Settings tab.
- If any user fields are defined with the parameter **Input** set to **True**, the user will be prompted to enter those values first.
- The Results Window shows the standard results plus any additional user fields defined by the user. If any of the user fields has a Statistics parameter defined (non zero) there will be a button next to it as in the following picture:



By pressing the  button, a graph will popup showing the acquired data points and the corresponding statistical parameters. These are the same parameters as can be referred to using the Statistics/DataCount, Statistics/Slope or Statistics/StandardDeviation parameters of the user field.

By using the  button after a measurement one can get a feel of the stability and noise of the measured parameters and also see which values are appropriate to use as constraints under the Statistics section of the user field in order for the measurement to be regarded as valid.



**Note!**

The slope parameter does not reflect the measured data variation over time, but rather over the number of measurements – I.e. doubling the integration time per data point will thus halve the slope.

If, during a measurement, the statistical requirements upon a user field are not met within the specified Statistics/Timeout period, the user field will become red. It will also not be possible to save the measurement to the log.

The figure shows a "Results Window - Timeout!" dialog box. It is divided into two main sections: input parameters on the left and results on the right.

Parameter	Value
Phase (min)	-3903,03
Correction factor	0,00026
Connection	X1-X3
Nominal ratio	1200
Notes	
<b>RESULTS</b>	
Voltage	5,097 mV
Frequency	49,96 Hz
Current	506,9 pA
Ratio1	315,578 m
Phase1	-1,13534 rad

At the bottom of the dialog, there are two buttons: a green "SAVE" button and a red "CANCEL" button.