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Instruction Manual

DELTA4000

12-kV Insulation Diagnostic System

HIGH VOLTAGE EQUIPMENT
Read this entire manual before operating.

Megger.

Valley Forge Corporate Center
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www.megger.com

DELTA4000

12-kV Insulation Diagnostic System

The information presented in this manual is believed to be adequate for the intended use of the product. If the product or its individual instruments are used for purposes other than those specified herein, confirmation of their validity and suitability must be obtained from Megger. Refer to the warranty information below. Specifications are subject to change without notice.

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. 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. 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 abuse (failure to follow recommended operating procedures) or failure by the customer to perform specific maintenance as indicated in this manual.

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Megger.

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Introduction

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 manual.

General Information

The DELTA4000 is used for shop and field testing of high-voltage electrical insulating systems at test voltages up to 12 kV. Test results can be used to evaluate the nature and quality of electrical insulating materials and manufacturing processes to reveal contamination, fractures, punctures, and other defects that accompany the aging of insulation. The test set comprises of a control unit, a high-voltage unit, cables, and canvas carrying bags. Refer to the Specifications section for a list of included accessories.

Tests are made by measuring the capacitance and dissipation factor (power factor) of a specimen. The values measured will change when undesirable conditions exist, such as moisture on or in the insulation; presence of conductive contaminants in insulating oil, gas or solids; presence of internal partial discharges etc.

The test set measures insulation properties in high-voltage power equipment such as transformers, bushings, rotating machines, cables, circuit breakers, capacitors, surge (lightning) arresters etc. In addition the test set can also measure transformer excitation current and transformer turns ratio (with optional TTR capacitor).

Delta4000 makes all standard Ungrounded Specimen Tests (UST) and Grounded Specimen Tests (GST) on high-voltage apparatus and key features include:

- Two-piece design for easy transportation Rugged and robust and only 14+22 kg (31+48 lb)
- Performs all standard UST and GST tests
- Handling up to 15 mA interference current into any lead of the instrument or a signal to noise ratio of 1:20, secures stable readings and correct data even in the highest interference switchyards.
- Standard 50/60 Hz measurements as well as 1-500 Hz frequency sweep reveals more details in the insulation characteristics
- Advanced signal acquisition and noise suppression circuitry results in 25-50% shorter measurement times
- Intelligent temperature compensation (ITC) feature enables an accurate temperature correction of measurements taken at high and low temperatures. No more average table corrections but instead a true correction based on the actual type and condition of the insulation (standard tables also provided for comparison with previously measured data)
- Voltage Dependence Detection (VDD). Delta4000 will automatically detect if the test specimen has voltage dependence and suggest the user to do a tip-up test.
- Two operation modes; Form-based, automated testing with PowerDB or run your specific test manually controlled with Delta Control.
- Enhanced safety features with safety hand switches, foot switch and warning strobe light
- Optional resonating inductor provides capability of testing high capacitance samples at high voltage.

2

Safety

Precautions

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 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.

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. A safety ground jumper must then be installed between all terminals of apparatus under test and ground. 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.

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 to ground from the live and neutral poles of the power source must be within the following rated operating voltage:

100-240 V ± 10 %, 50/60 Hz, 16A

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.

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.

- 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.
- Never connect the test set to energized equipment.
- 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 construction and operation of the test set and the hazards involved.
- Refer to e.g. IEEE 510 - 1983, "IEEE Recommended Practices for Safety in High-Voltage and High-Power Testing," for information.

As a routine safety procedure some users require that rubber gloves be worn, not only when making connections to the high-voltage terminals, but also when manipulating the controls.

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.

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:

WARNING

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

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

Specifications

Technical Specifications

Input Power:	100-240 V ± 10 %, 50/60 Hz, 16 A max
Output voltage:	0 to 12 kV, continuously adjustable
Test frequency range:	45-70 Hz (12 kV)
	15-405 Hz (4 kV)
	1-505 Hz (250 V)
Output power:	3.6 kVA
Output Current:	>100 mA, continuous output
	>300 mA, up to 4 minutes
	The output current capacity can be expanded to 4 A using the optional Resonating Inductor, catalog number 670600

Measuring Ranges:

Voltage:	25 V to 12 kV, 1 V maximum resolution
Current:	0 to 5 A, 0.1 μA maximum resolution
	The measurement can be corrected to either 2.5 kV or 10 kV equivalents
Capacitance:	0 to 100 μF, 0.01 pF maximum resolution
Inductance:	6H to 10MH, 0.1 mH maximum resolution

Power Factor:	0 to 100%, 0.001% maximum resolution
Dissipation Factor:	0 to 100, 0.001% maximum resolution
Watt Loss:	0 to 2 kW, actual power, 0 to 100 kW when corrected to 10 kV equivalent. 0.1mW maximum resolution. The measurement can be corrected to either 2.5 kV or 10 kV equivalents.
Temperature Correction:	Intelligent temperature correction (ITC) from 5°C to 50°C test temperature to 20°C reference Standard tables for temperature corrections

Accuracy:

Voltage:	±(1% of reading + 1 digit)
Current:	±(1% of reading + 1 digit)
Capacitance:	±(0.5% of reading + 1 pF)
Inductance:	±(0.5% of reading + 1 mH)
Power Factor:	±(0.5% of reading + 0.02%)
Dissipation Factor:	±(0.5% of reading + 0.02%)
Watt Loss:	±(1% of reading + 1mW)

Noise Immunity:

Electrostatic:	15mA induced noise into any test lead with no loss of measurement accuracy at maximum interference to specimen current of 20:1
Electromagnetic:	500 μT, at 50 Hz in any direction

Computer Interfaces:	
Printer:	USB
Communication:	Ethernet and USB
User Interface (Delta4310 on-board computer model):	8.4 in., full-color VGA, test forms on-screen view, full QWERTY keypad and navigational pushbuttons
Data Storage:	
Internal computer:	Up to 100,000 data sets
External:	Pending external computer and/or flash memory size
Control Software:	PowerDB and Delta Control
Safety Qualifications:	IEC/ANSI 61010-1
Environment:	
Temperature:	Operating: -20 to +55° C
	Storage: -50 to +70° C
Relative Humidity:	Operating: 0 to 90% non-condensing
	Storage: 0 to 95% non-condensing
Shock and vibration:	ASTM D999.75
EMC:	EN 61326-1
Dimensions:	
Control Unit:	290 x 290 x 460 mm (not including handles)
High Voltage Unit:	290 x 290 x 460 mm (not including handles)

Weight:

Delta4100 Control Unit (to be used with external computer):	14kg (33lbs)
Delta4300 Control Unit (with on-board computer):	15kg (31lbs)
Delta4110 HV Unit:	22 kg (48lbs)
Standard cables:	15 kg (33lbs)

Test Modes

Delta4000 supports the following test modes:

UST: Ungrounded Specimen Testing			
Test mode	**Measure**	**Ground**	**Guard**
UST-R	Red	Blue	---
UST-B	Blue	Red	---
UST-RB	Red and Blue	---	---
GST: Grounded Specimen Testing			
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

Maximum Specimen Capacitance

Table 1 shows the maximum measurable specimen capacitance at various voltages and loading time. This can be increased up to 1.2 F at 10 kV (50 Hz) test voltage using the optional Resonating Inductor.

Table 1: Maximum Measureable Specimen Capacitance at 50/60Hz

Test Volts (kV)	Maximum Capacitance (µF) (100 mA continuos service)		Maximum Capacitance (µF) (300 mA for 4 minutes)	
	60 Hz	50 Hz	60 Hz	50 Hz
0.025	11	13	32	38
0.05	5.3	6.3	16	19
0.1	2.6	3.2	7.9	9.5
0.25	1.1	1.3	3.2	3.8
0.5	0.53	0.63	1.6	1.9
1	0.26	0.32	0.79	0.95
2	0.13	0.16	0.40	0.48
3	0.09	0.11	0.27	0.32
4	0.065	0.080	0.20	0.24
5	0.11	0.063	0.16	0.19
6	0.044	0.055	0.13	0.16
8	0.033	0.040	0.099	0.12
10	0.027	0.032	0.080	0.095
12	0.022	0.027	0.066	0.080

Safety Features

Safety features include;

- External hand or foot (optional) interlock switches must be closed to energize high-voltage circuit.
- Dual ground required to energize high-voltage circuit.
- Circuit breaker for short-circuit protection.
- All controls at ground potential.
- Over-voltage protective devices prevent damage to test set in the event of specimen breakdown.
- Low-voltage inputs are grounded when the test set is turned off or between measurements.

Accessories

Included Accessories

High voltage lead: 21 m (70 ft), double shielded	30012-11
Measurement lead, color-coded red	5572-1
Measurement lead, color-coded blue	5572-2
Ground lead: 9 m (30 ft)	002-131
Mains cable 16A EU	7032-19
Mains cable 16A US	7032-20
Mains cable 16A UK	7032-21
Mains cable 16A no plug	7032-22
Safety hand switch, Interlock #1: 18 m (60 ft)	1001-850
Safety hand switch, Interlock #2: 2.5 m (8 ft)	1001-851
HV unit power cable, 1 m (3 ft)	2002-132
HV unit control cable, 1 m (3 ft)	2002-133
Ground lead cable, 1 m (3 ft)	2002-134
USB cable, 3 m (10 ft)	2002-135
Ethernet cable, CAT 5, 3 m (10 ft)	2002-136
Soft padded carrying case for control unit [1]	2001-766
Soft padded carrying case for HV unit [1]	2001-766
Soft case for HV cable	2001-507
Soft case for other cables/accessories	2001-506
User manual	81331
Application guide	81332
Warranty [1 year]	
PowerDB Advanced software with Delta Control	

Optional Accessories

Safety foot switch	1001-852
External strobe	Y37181
External strobe extension cable, 18 m (60 ft)	1001-853

Transport case, 2-piece design	
Case for control unit and accessories [1]	2001-746
Case for HV unit and accessories [1]	2001-746
Transport case, 3-piece design	
Case for control unit [1]	2001-791
Case for HV unit [1]	2001-791
Case for accessories [1]	2001-792
Transport cart / trolley	1001-530
Calibration box set for CAL4000	2002-137
Calibration standard	670500-1
Transit cases for calibration standard	670635
HV TTR capacitor, single phase (10 nF, 10 kV)	36610
HV reference capacitor (100 pF, 10 kV)	36610-1
HV reference capacitor (1000 pF, 10 kV)	36610-2
Carry case for capacitors	36610-CC
Capacitor kit (TTR cap, 2 ref caps, carry case)	36610-KIT2
Resonating inductor	670600-1
Thermal Pentax® printer, 120 V	36493-1
Thermal Pentax® printer, 240 V	36494-1-KIT
Thermal paper (8.5" x 11") for printer	36809-1
Thermal paper (A4) for printer	36809-2
Oil test cell	670511
Hot collar belts [3]	670505
Bushing tap connectors [2]	670506
External temperature and humidity probes	2002-138
USB bar code wand and software	36528
Accessory kit: hot collar straps [3], external temperature and humidity meters, .75" bushing tap connector [1], 1" bushing tap connector [1], mini bushing tap connectors [2], "J" probe bushing tap connector [1], 1 m (3 ft) non-insulating shorting lead [3], 2 m (6 ft) non-insulating shorting lead [3]	670501

Special length cables available upon request. Consult factory.

4

Controls, Indicators, and Connectors

Control Unit Side Panel

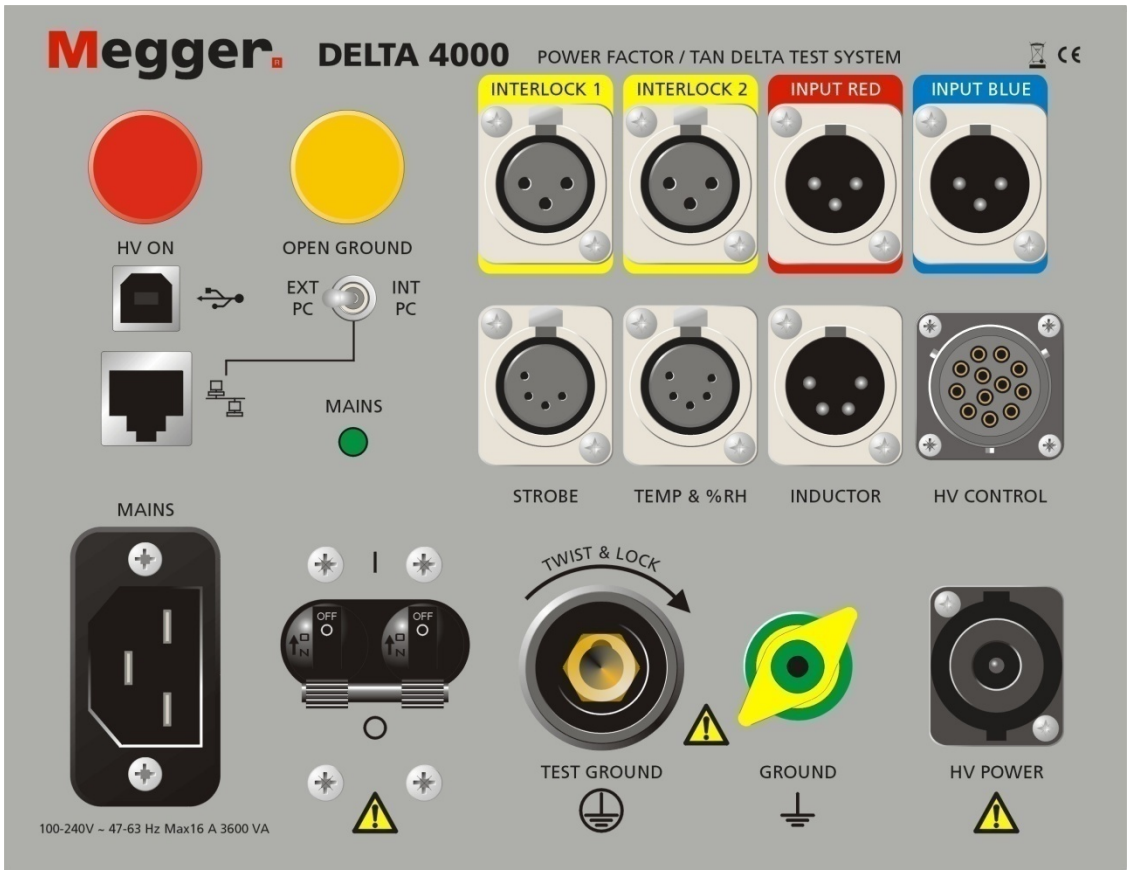


Figure 1: Side Panel – Control Unit

	**HV ON**	Warning signal indicating that the HV unit is active
	**OPEN GROUND**	When lit, this yellow lamp indicates an open in double ground system or defective grounding of test set.
	**SAFETY INTERLOCK 1 and 2**	Two plug receptacles for connecting external interlock switches. Two hand interlock switches and a foot switch are supplied; however, in the event that a hand interlock is replaced with a test area interlock, the system must be constructed so that the interlock switches are closed when the test area gate or gates are closed. The interlock wiring must be run as a twisted pair to minimize electromagnetic coupling into the system. This interlock system should be wired such that connection is made to the A and B sockets of the SAFETY INTERLOCK receptacle. When the interlock loop is opened the test is automatically terminated.
	**INPUT RED**	Plug receptacle for connecting the red low-voltage test lead.
	**INPUT BLUE**	Plug receptacle for connecting the blue low-voltage test lead.
	**USB port**	Receptacle for computer communication.
	**Ethernet port**	Receptacle for computer communication.
	**Ext-Int PC switch**	Switch for selecting internal or external PC (functional on Delta4310 only, disabled on Delta4110). "Internal" connects the on-board PC to Delta via Ethernet, "External" means that you can operate Delta from an external computer.

	**STROBE**	Receptacle for connecting the warning strobe light
	**TEMP and %RH**	Receptacle for connecting the temp and humidity sensor (optional accessory)
	**INDUCTOR**	Receptacle for connecting the test set to an optional Resonating Inductor (Cat. No. 670600) for extended capacitance range.
	**HV CONTROL**	Receptacle for the control cable between the control and HV units
	**MAINS**	Receptacle for connecting the test set to an AC power source as marked on panel.
	**TEST GROUND**	Receptacle for connecting the test ground cable between the test set and ground (normally station ground) near the test object
	**GROUND**	This wing nut is for connecting an additional safety ground between the control and HV units or to ground external objects e.g. optional trolley
	**HV POWER**	Receptacle for the power cable between the control and HV units

High Voltage Unit Connector Panel

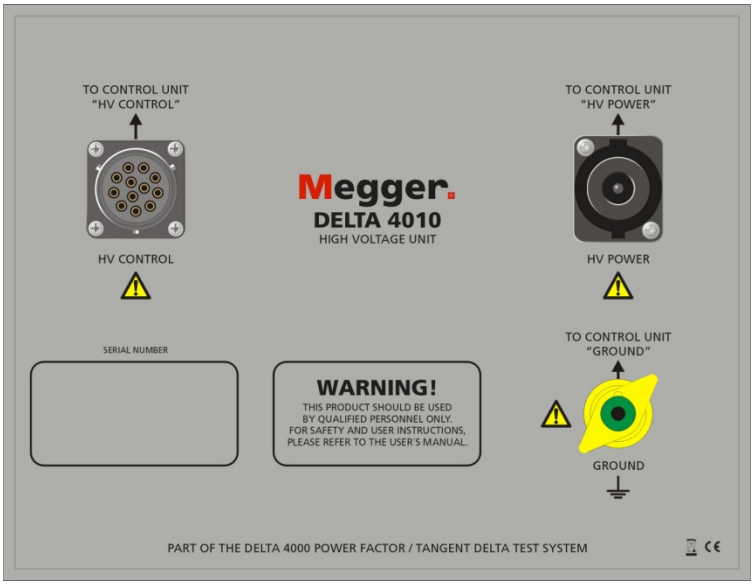


Figure 2: Connector panel – HV Unit

	**HV CONTROL**	Receptacle for the control cable between the control and HV units
	**HV POWER**	Receptacle for the power cable between the control and HV units
	**GROUND**	This wing nut is for connecting an additional safety ground between the control and HV units
	**HV Output**	Receptacle for the high voltage cable (located on the side exterior of the equipment box)

NOTE:	*The HV cable is connected on the other side of the unit. Note the sliding locker to secure the cable. Do NOT use force to plug in-out!*

5

Setup and Operation

Safety Precautions

Warning

The output of this test set can be lethal.

As with any high-voltage equipment, caution must be used at all times and all safety procedures followed. Read and understand Section 2, Safety, before proceeding. Be sure that the test specimen is de-energized and grounded before making connections. Isolate power equipment to be tested from the high-voltage busbars and attach necessary grounds to floating busbars in accordance with standard company policy, observing all safety procedures. Make certain that no one can come in contact with the high-voltage output terminal or any material energized by the output. Be aware that when testing power cables high voltage will be present at the remote end of the cable. Use protective barriers if necessary. Locate the control unit and high-voltage unit in an area which is as dry as possible. Maintain adequate clearances between energized conductors and ground to prevent arc-over. Such accidental arc-over may create a safety hazard or damage the equipment being tested.

Setup

The following steps are a general guide for setting up the test set. Figure 6 shows a typical setup for testing inter-winding and ground capacitance on a three-phase delta-wye power transformer; Figure 7 shows a typical setup for making excitation current measurements on the same transformer. The test set controls and connectors are identified in Figures 1 through 5. Refer to the Application Guide for specific instructions on connecting this and other power equipment to the test set.

When making capacitance measurements on transformer windings always short each winding on itself with a jumper lead to eliminate winding inductance effect. The shorting wire is usually non-insulated and must not be in contact with any other insulated or non-insulated parts of the transformer.

When making transformer excitation current measurements conduct all tests on high-voltage windings only. This reduces the required charging current. In load tap changers, set to fully raised or fully lowered position for routine tests.

WARNING

There is always the possibility of voltages being induced at the terminals of a test specimen because of proximity to energized high-voltage lines or equipment. A residual static voltage charge may also be present at these terminals. Ground each terminal to be tested with a safety ground stick, then install safety ground jumpers, before making connections.

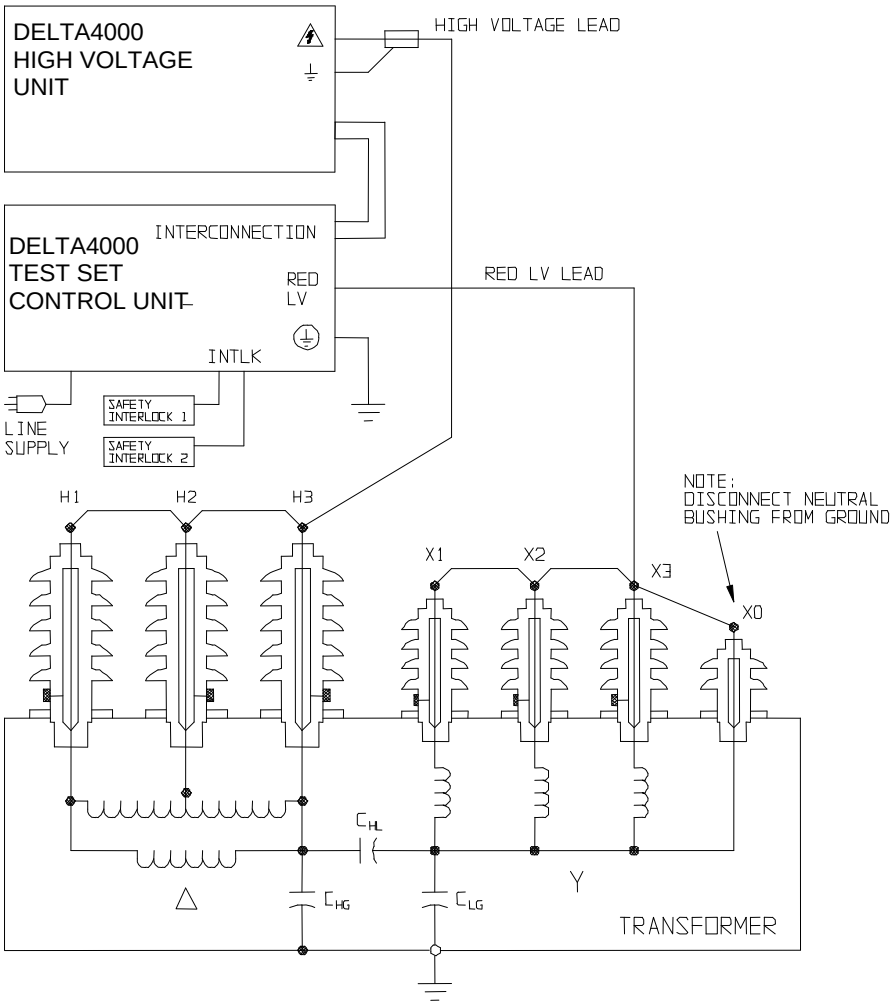


Figure 6: Typical Test Setup for AC Insulation Testing of a Three-Phase Two-Winding Power Transformer

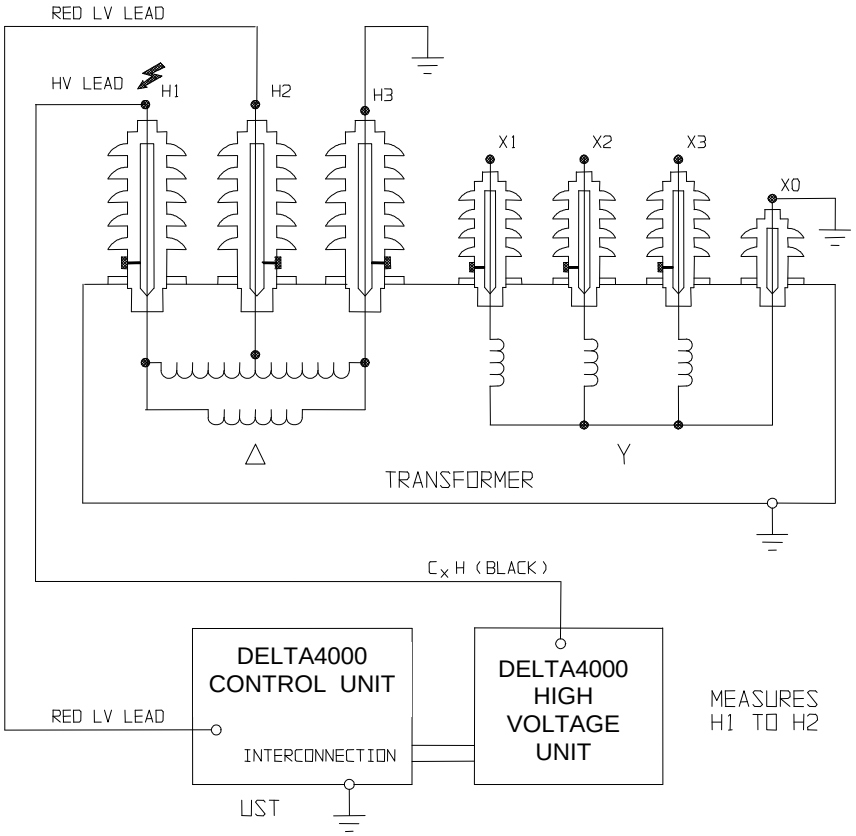


Figure 7: Typical Test Setup for Transformer Excitation Current Measurements

1. Locate the test set at least 6 ft (1.8 m) from the specimen to be tested.

2. Connect the test ground to a low impedance earth ground on the specimen (if possible). This should always be the first cable connected and last removed

3. Connect the control and power cables between the control and HV units. Make sure that the bayonet type plugs are fully locked on the receptacles.

4. Connect the measurement cable with the red colored boot to the INPUT RED receptacle. Make sure the connector locks to the receptacle. If required, connect the measurement cable with the blue colored boot to the INPUT BLUE receptacle.

5. Connect the external interlock cables or a test area interlock system to the INTERLOCK 1 and 2 receptacles. Make sure the plugs are fully seated and locked on the receptacles.

6. Connect the high-voltage cable to the high-voltage terminal of the high-voltage unit (be sure that the connector locks in place).

7. With the main breaker OFF, plug the input power cord into the test set power receptacle and into a three-wire grounded power receptacle having the appropriate voltage and current ratings.

8. When using a generator as a power source, note that the generator itself should be grounded to a suitable earth ground. If this is not done properly, the high-voltage circuit of the test set will be disabled. The voltage supplied to the Delta4000 is not critical but should be within the specified voltage range and frequency.

9. Connect the crocodile clip of the measurement cable to the desired terminal of the test specimen.

10. Connect the hook (or clip) of the high-voltage test cable to the desired terminal of the test specimen.

11. Remove all safety grounds from the specimen to be tested.

12. Start Delta4000 by closing the main breaker.

For Delta4110 with external computer:

13. Connect the Ethernet (or possibly USB, Ethernet is preferred) cable between Delta4110 and the computer

For using Delta Control SW:

14. Start Delta Control SW. A "connect to Delta" screen will appear. Select USB or Ethernet communication.

15. For TCP/IP (Ethernet) you need to search for the HW. A new screen will open and the SW will automatically detect the Delta address that you can select and connect to.

16. The Delta Control screen will appear.

For using Power DB SW:

17. Start Power DB SW

18. The connect procedure will appear when you start the first test.

Delta4310 with internal computer is internally connected to the Delta HW when the internal/external PC switch is set to "internal". In case you want to use Delta4310 with an external computer set the switch to "external" and connect the PC to the Ethernet or USB port.

Pending what model of Delta4000 you are using and if testing is performed automatically with PowerDB or manual with Delta Control SW, the actual testing procedure will vary. The following sections describe how to use Delta4000 with external or internal computer using Delta Control and PowerDB SW.

6

Delta Control User Interface

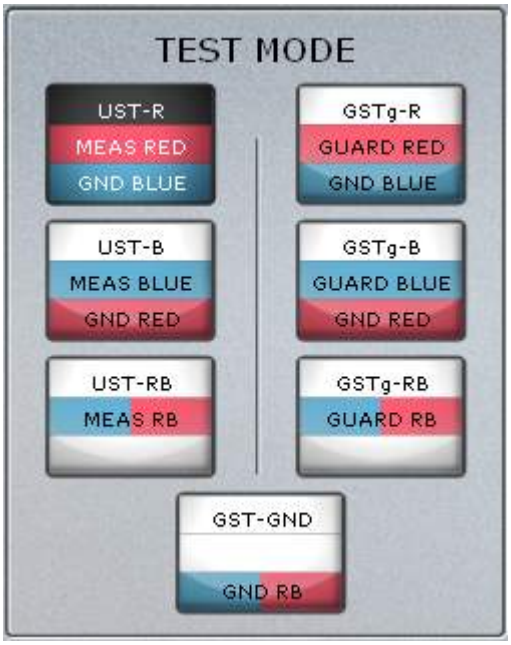
Introduction

The Delta Control software is an intuitive manual user interface where every feature is easy to identify. The buttons look like regular buttons on a mechanical front panel making the user feel as if he is using the instrument in a manual mode. The software can be operated using a touch screen or mouse control simply by clicking on the buttons. You may also "tab" between buttons using the keyboard. The buttons changes its look as you push the button so it is easy to know which key or function that is activated. All regular functions can be reached from this main screen/panel. Some buttons activates a popup screen where specific values and/or configurations can be set.

The Manual Control SW can be used as a test setting console in PowerDB or started as a separate program outside PowerDB.

Operation

Test Mode



Delta 4000 offers a quick setting for available test modes.

The top line (UST-R in this case) defines and describes the selected test mode.

The second and third lines explain how the instrument is configured for the measurement. They have a different designation depending on if UST (Ungrounded Specimen Test) or GST (Grounded Specimen Test) measurements are conducted.

UST mode

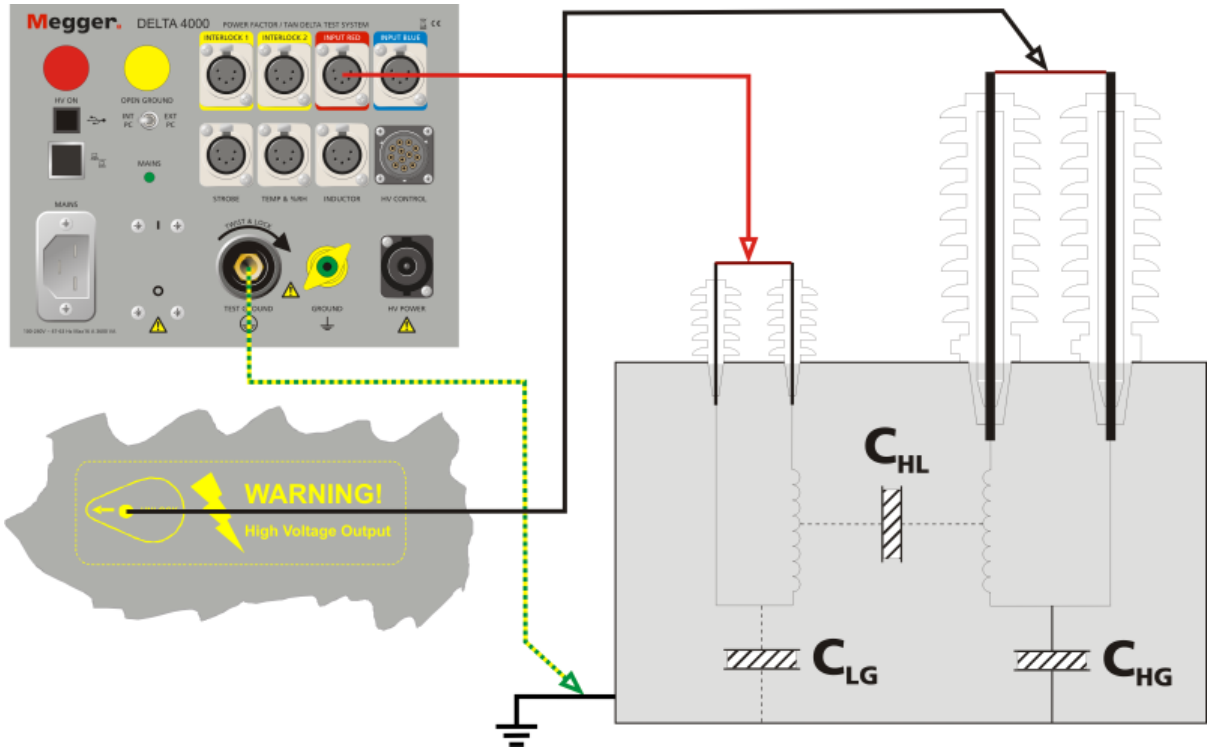
Ground and Guard are internally connected. Red and Blue terminals are either internally connected to be measured or internally connected to Ground (and Guard). In UST mode, the center line refers to the terminal or terminals that are measured and the lower line refers to the terminal that is internally connected to Ground and therefore excluded from the measurement.

GST mode

The current returning from Ground is measured. The Red and Blue terminals are either connected to Ground to be included in measurement or Guard to be excluded from the measurement.

Test Mode Examples

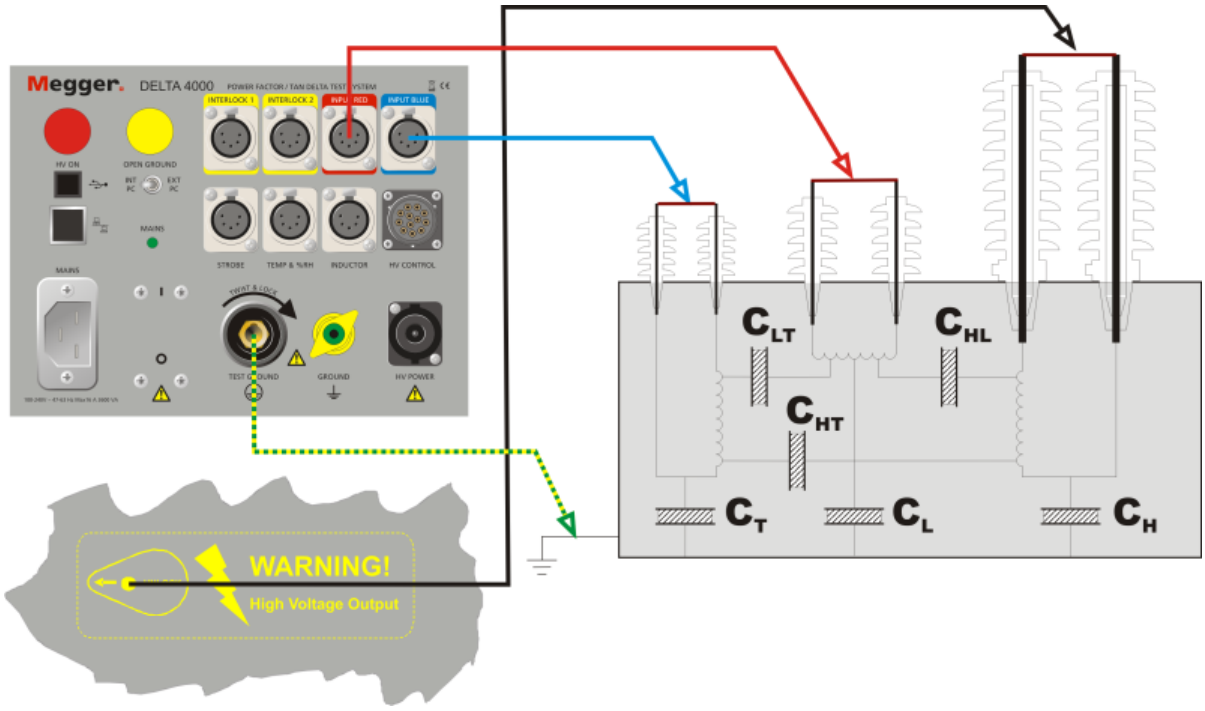
Two winding transformer test



When UST-R is used for the CHL test, the HV output terminal is to be connected to the primary winding and the red terminal to the secondary winding. The blue terminal does not have to be connected in this case.

Three winding transformer test

When UST-R is selected for a CHL test, the HV output terminal is to be connected to the primary winding, the red terminal to the secondary winding and the blue terminal to the tertiary winding. The blue terminal is in this case grounded/guarded.



For CHT measurement UST-B should be selected. The blue terminal is now measured and the red is grounded. The time saving benefit is that the transformer can be tested without the need for reconnections.

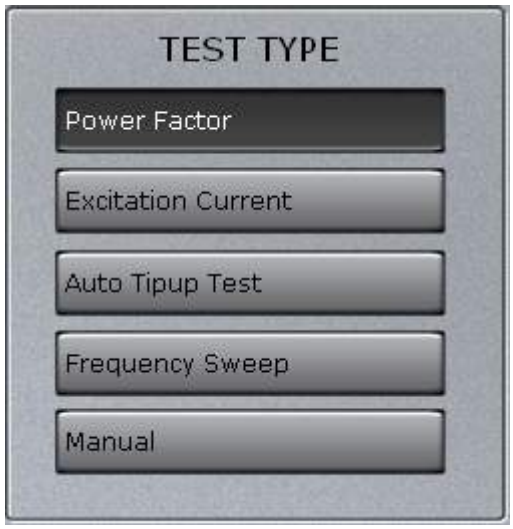
Frequency and Temperature

This is where you specify at which test frequency you want to perform the test. This is in most cases the same as the network frequency (but if you would like to test at e.g. 55 Hz you simply enter 55). Note that "Line Frequency" in the setting tab must be set to actual line frequency, 50Hz or 60 Hz.

Insulation properties are temperature dependent and the test object temperature is a very important parameter. The average temperature of the test object insulation should be entered.

These two parameters need to be set in order to start a measurement.

Test Type



Select which Test you want to perform. In the setting tab you set your preference for tan delta or power factor readings.

The available tests are:

Power Factor/Tan-Delta	Power Factor or Tan-Delta test is a semi automatic test sequence performed at a preset voltage and line frequency. The system will ramp up the voltage to the set voltage and measure the Power Factor or Tan-Delta and after the completed test, ramp voltage down and stop the test and present the result.
Excitation Current	An excitation current is a standard test that is helpful in determining winding or core problems in transformers.

Auto Tip-up Test	Tip-up testing is used for testing power components with voltage dependent dissipation factor (e.g. generators) or in case a voltage dependence is suspected and indicated by high VDF in Delta4000. The highest voltage level used is set on main page and the voltage per step is set on the settings page Voltage steps can be set on the settings page
Frequency Sweep	Frequency Sweep allows the user to perform a series of tests over a frequency range. The voltage level used is set on main page and the voltage per step is set on the settings page. Note that there are limitation of voltage levels at high frequencies and low frequencies below 45 Hz
Manual	This mode allows continuous manual control of output voltage.

Voltage Control

The voltage control has three sections.

The top section is the voltmeter that shows the voltage in real time. Under the voltmeter is a display showing the set voltage (target voltage). You can click on this display to enter the target voltage or increase or decrease it using the buttons in the centre control. Below the display area is a round control where you can manually adjust voltage up or down. The single arrows step up or down in steps of 100 volts while the buttons with two arrows steps up or down in steps of 1000 volts. The C button in the middle clears the selection.

Start and Stop

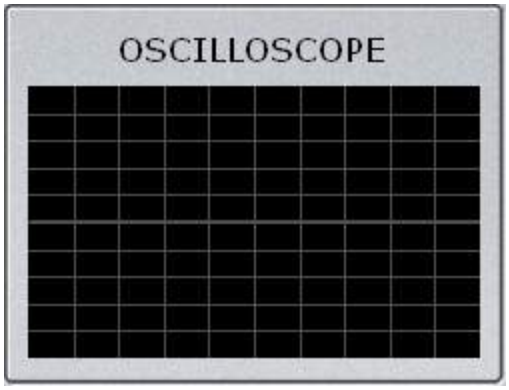
When you are ready to start measuring, press the Start button. In all modes except the Manual type, the measurement sequence is automatic and the result presented when finished. If you need to stop an ongoing measurement press the Stop button. Note: the Stop button stops the measurement smoothly, if stop by emergency reason, simply release the interlock in the interlock handle.

Note that the green light on the start button will not illuminate until both interlock switches are closed.

In manual mode you have a button for starting a measurement. The start button is used to activate the output. You can manually control output voltage using the Voltage control. You can record and store a value to the log at any time by pressing the Measure button.

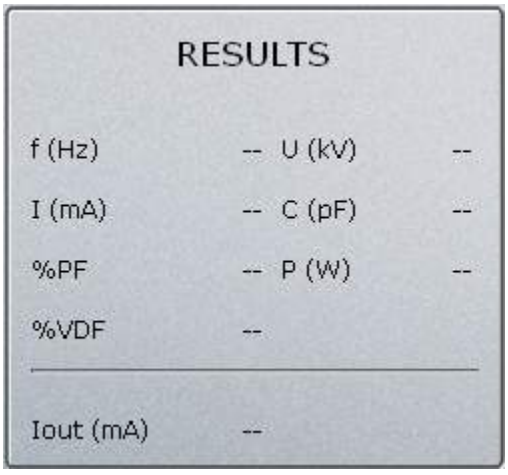
Press Stop or "Esc"to stop the output voltage.

Oscilloscope



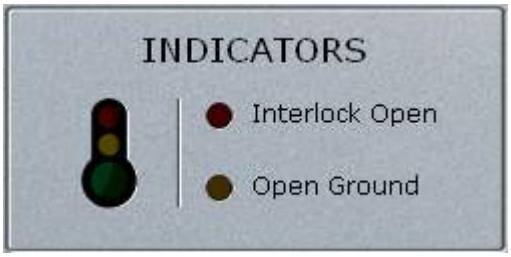
In the oscilloscope you can follow applied voltage (red) and a voltage proportional to measured current (white). Note that this feature is designed to be a signal monitor and not intended to be a measurement device. The display has auto scaling of amplitude and time axis.

Results



In the results panel you can see the result of the latest measurement.

Indicators



The indicators show if there are anything that prevents a measurement from starting. If the Interlock Open led is on, you have to close both switches before you can start a test. If the open ground led is on, you have to ensure that the ground potential of the test object and the instrument is the same. The measurement cannot start if any of these led's are turned on. The “greed”, “yellow”, “red” thermometer is related to internal instrument temperatures and %RH; Green is ok, yellow is warning and if red the unit will not operate. For more details open up the Status window click the Menu Status button.

Menu

In the menu you can access various extra functions.

Settings Access the default settings used in the program.

Graph Shows graph of performed measurements.

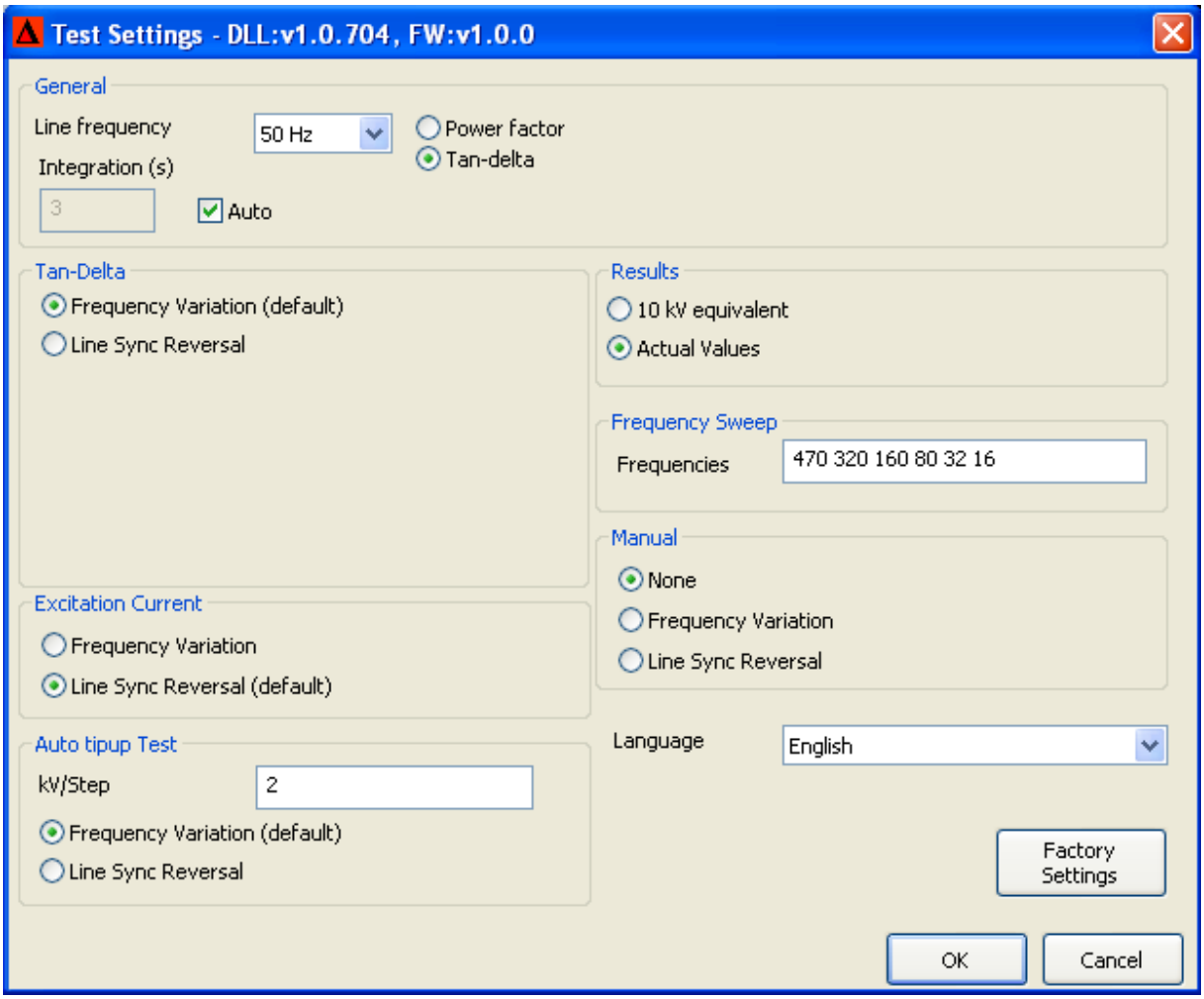
Log Show a log of measured values.

Help Shows a help file.

Status Accessing information about internal %RH, temperatures , serial numbers and SW/Firmware version.

Close Close/Shut down Delta Control

Settings



The Test Settings dialog allows for user preference and test sequence settings. The user can also reset the software to factory default settings by pressing the Factory Settings button in the lower right corner.

General

Under the general section you can change the default line frequency. Specify if you want to display the values as power factor or tan-delta. You can also change the integration time between 3 and 200 seconds or set it to automatic.

Power Factor/Tan-delta

Here you can select either frequency variation (default) or line sync reversal for noise suppression

Excitation Current

Here you can select either frequency variation or line sync reversal (default) for noise suppression

Auto tip-up Test

Set the kV/step for the auto tipup test. The software will automatically increase the voltage by the increment set in this box until the entered test voltage selected in the main screen is reached.

You can also select either frequency variation or line sync reversal for noise suppression

Results

Specify if you want the measured values presented as either 10 kV equivalent or the actual measured values.

Frequency Sweep

Set frequencies at which the frequency sweep will be made.

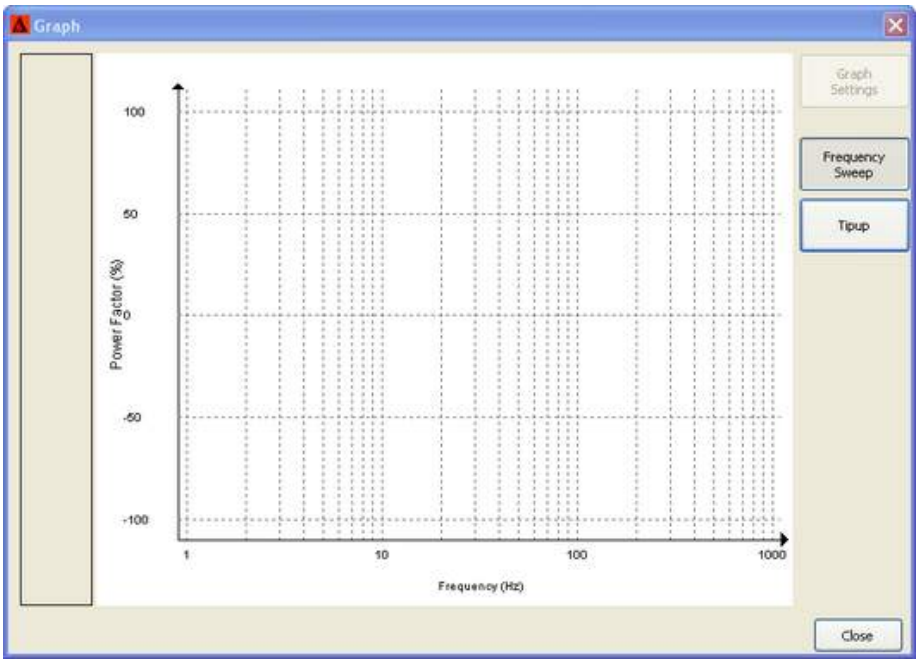
Manual

Select the rejection mode to be used during manual measurements.

Language

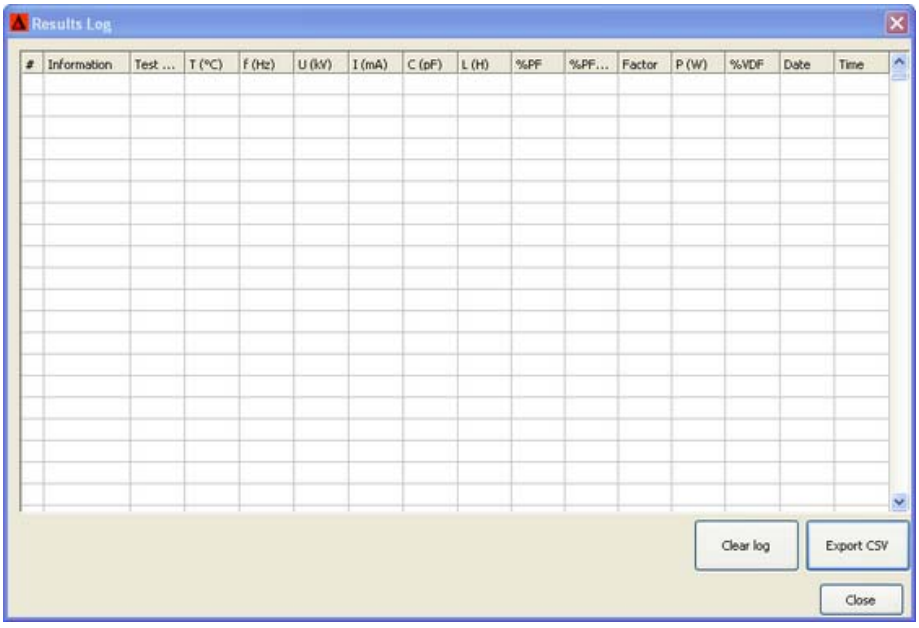
Set the language for the user interface of the software.

Graph



The graph dialog shows graphs of the measured values.

Log



The log shows all measured values from the performed tests.

The clear log button clears all measured values.

The Export CSV button makes is possible to export the log as a comma separated file for processing in other software or store for future reference. When exporting to CSV you can choose if you want to have a header or not and what type of decimal separator you want to use.

You may also mark suitable part of the log-fields and simply use cut (ctrl+c) and paste it into e.g. excel (ctrl+v).

7

PowerDB User Interface

Introduction

PowerDB Lite is a free, but limited capability, version of the PowerDB software tool that is designed specifically to control and/or extract data from Megger instruments. The primary difference between PowerDB Lite and PowerDB is that PowerDB is designed to work with other manufacturers' equipment and has field and office synchronization capabilities. PowerDB Lite will present your test data into a professional looking data form that can be sent to a printer or .pdf file distiller such as PDF995.

PowerDB Lite allows you to use a sub-set of the standard PowerDB forms that are appropriate for specific Megger instruments. PowerDB Lite detects the instrument and enables the appropriate form(s). Data is captured directly while using the test instrument. Completed data forms are saved as files to your computer.

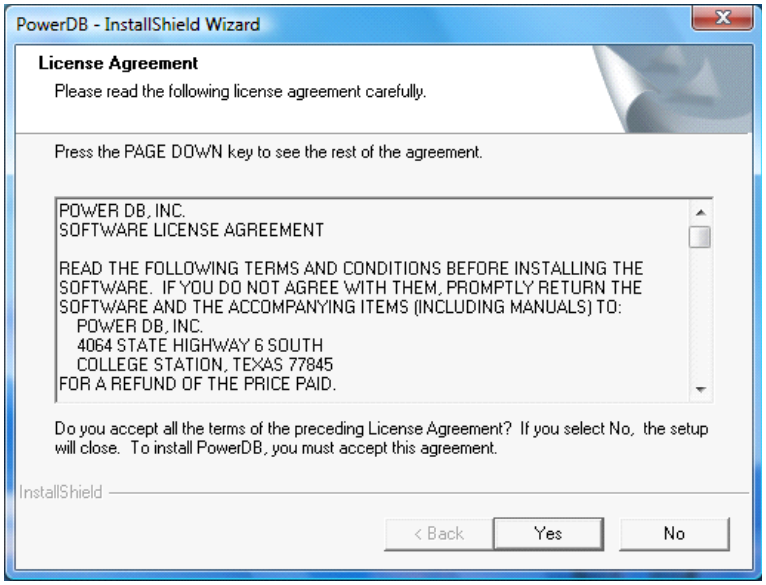
Minimum Recommended System

Operating System:	Windows XP or later
RAM:	64 MB RAM minimum, 512+ MB RAM recommended
Processor:	300 MHz Pentium Class processor minimum, 1 GHZ or better recommended

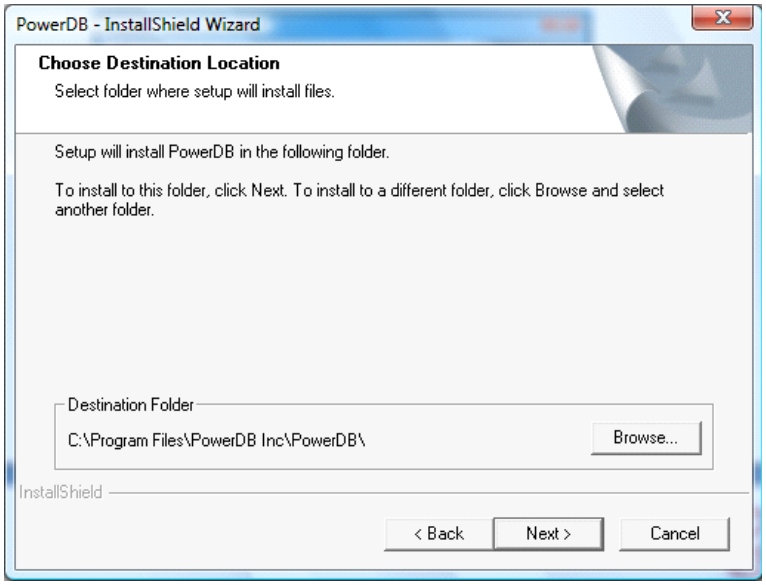
Software Installation

To install PowerDB Lite, load the PowerDB Lite CD into your CD-ROM drive and follow the on-screen instructions.

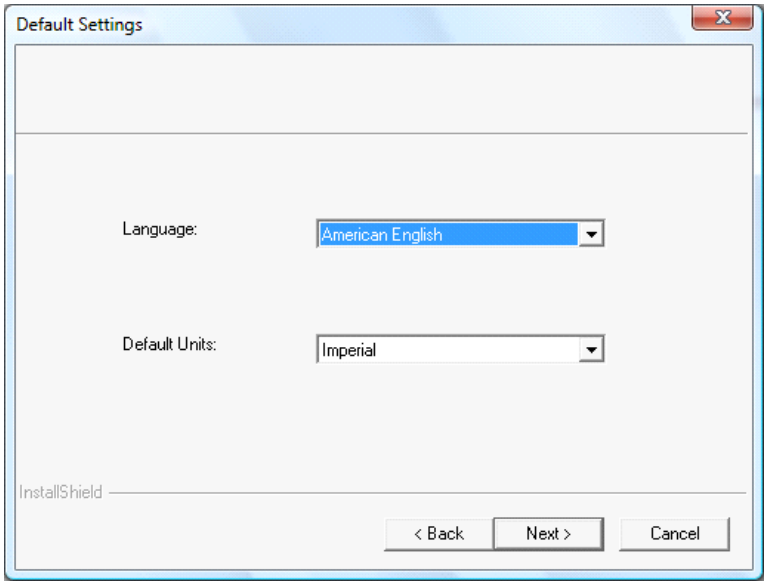
1. Accept the terms of the License agreement.



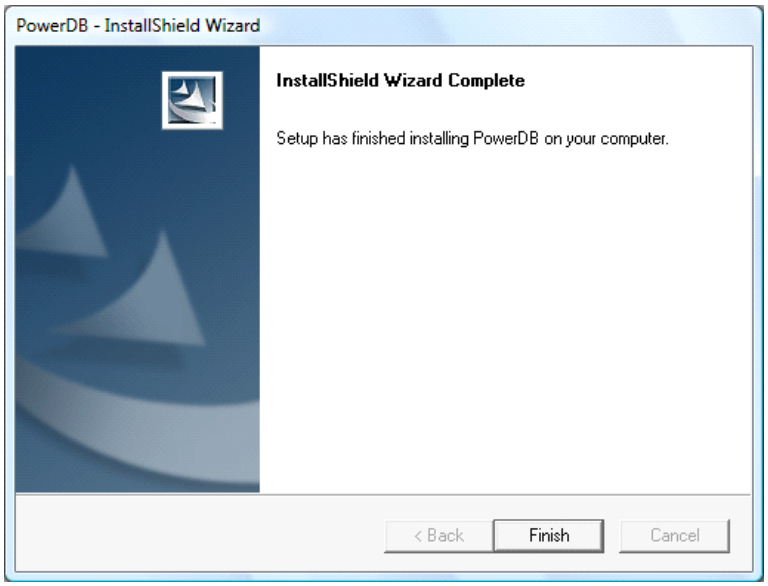
2. Choose the destination location for the PowerDB Lite files.



3. Select Default Settings.



4. InstallShield Wizard will complete the installation of PowerDB Lite. Click Finish to close the installation program.

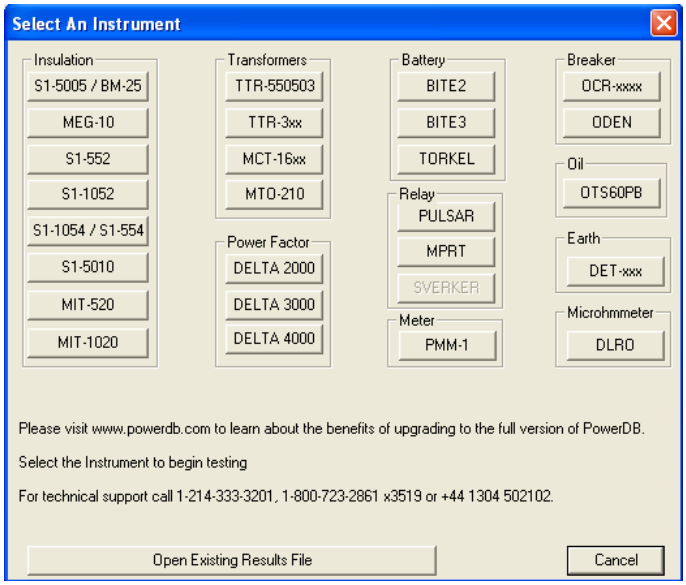


NOTE:	*To run the Delta4000 with PowerDB you must also install the Delta Control SW.*

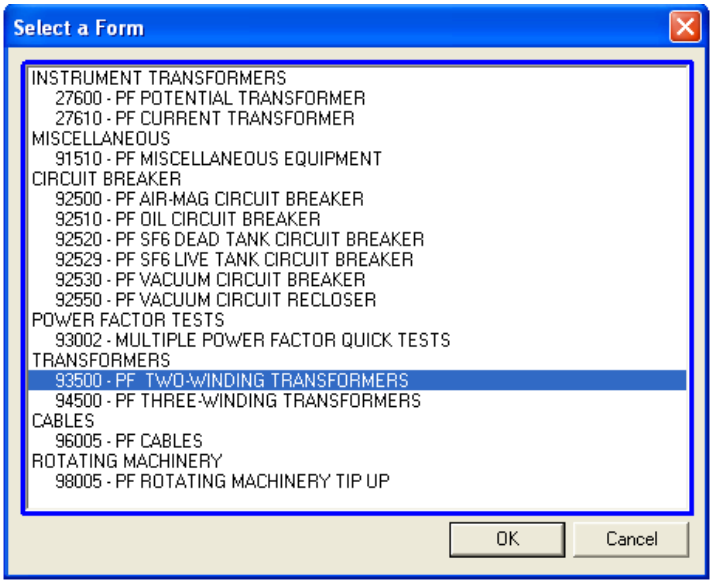
To install Delta Control, load the SW CD into your CD-ROM drive and follow the on-screen instructions.

Using Delta4000 with PowerDB

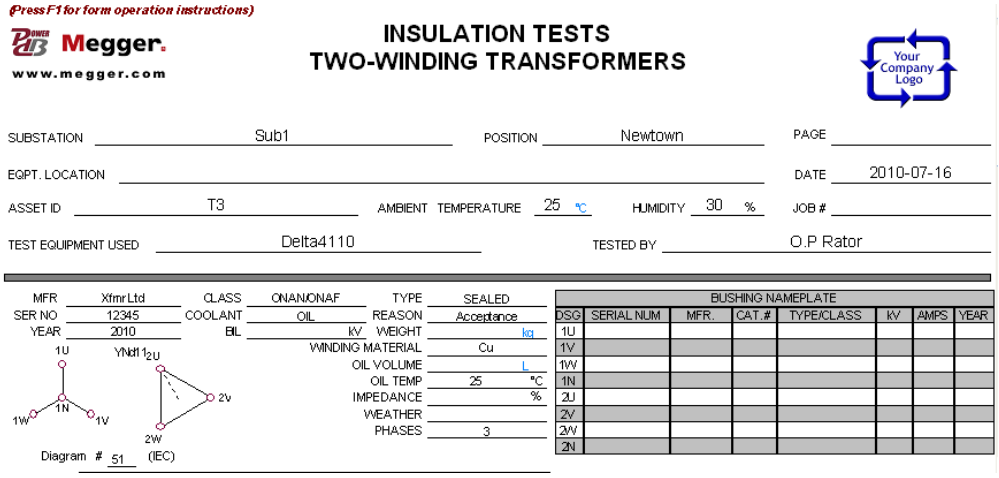
1. Start the program and select Delta4000 in the Instrument Setup screen. If you already have tested this object at an earlier occasion, open up this file instead using "Open Existing Results File". PowerDB is designed to save data from several tests on one object in same file. Please note that Delta Control SW must also be installed to be able to run Delta4000 and perform measurements. Viewing and reporting previous measurements can be done on a computer without a Delta Control installation and without connecting to the HW.



2. Select a form to be used for the test.



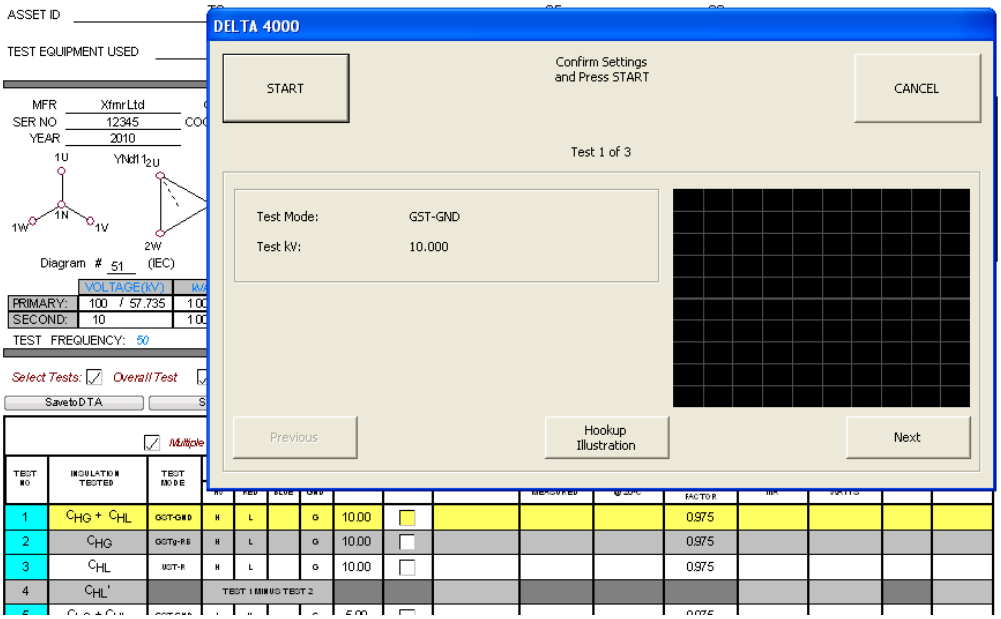
3. Enter nameplate/test object/test conditions data into the form.



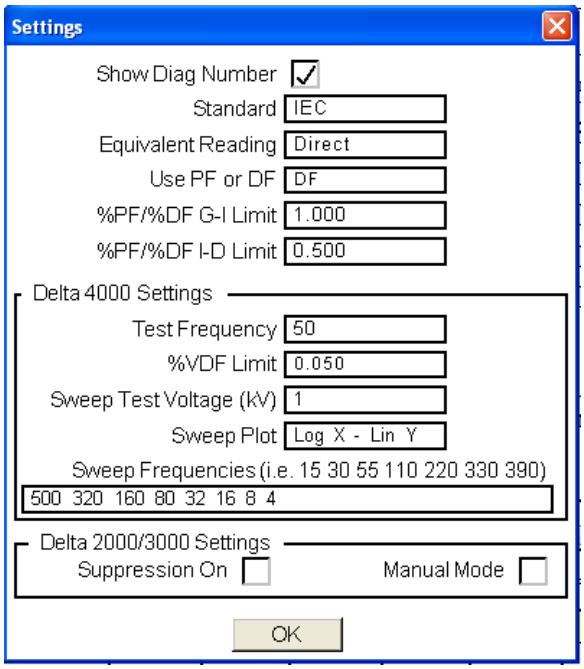
4. When testing is ready to be performed, the test can be started by;

- Right-click the desired blue highlighted test number
- or press F2 when the actual test row is activated (highlighted in yellow)
- or for Delta4310 press the "Test" button when the actual test row is activated

A pop-up screen will appear with selected test parameters. Click the start button to start the test



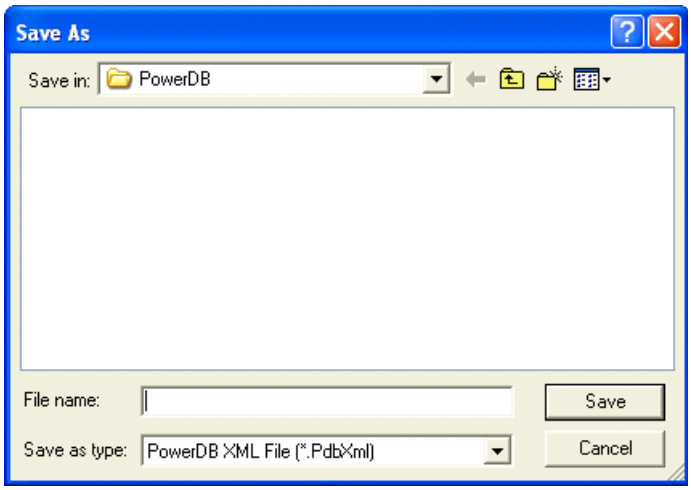
5. To change the settings of the Delta4000, use the "Settings" button or place the mouse on the test form background, right-click and then select "Power Factor Settings".



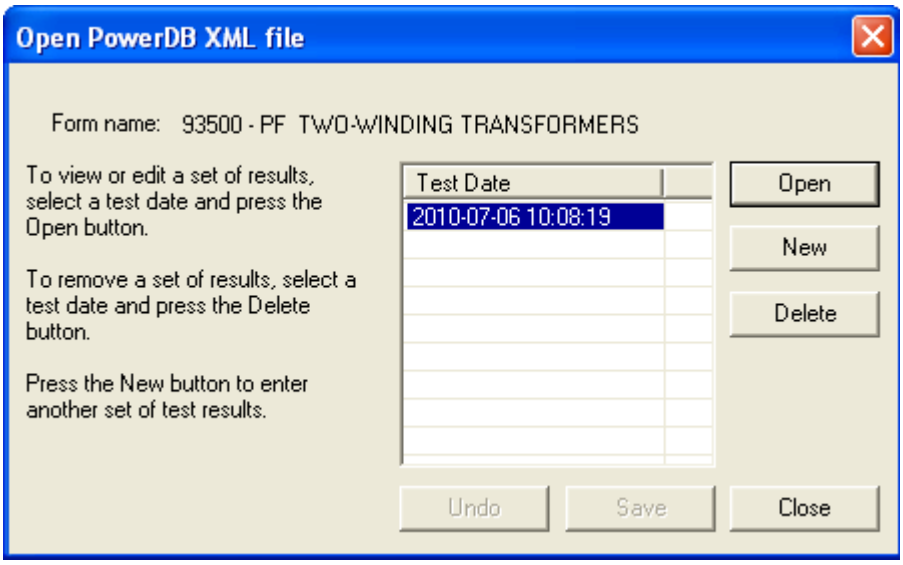
6. Saving the data

a. Before the first test is performed, PowerDB will ask where to save your form with the measured data

b. The Save As screen will allow you to specify a location and file name for your PowerDB Lite XML file.



7. Open a previously performed test by opening the file in your selected folder. A pop-up screen will appear, listing all measurements for this object, and you can open the individual measurement in PowerDB or perform a new test.



8. Setting the Logos on the PowerDB form

a. Select the Tools>Options menu item.

b. The Logos section specifies paths to the left and right logos files to use.

c. To change the left logo press the "…" button by the left logo path.

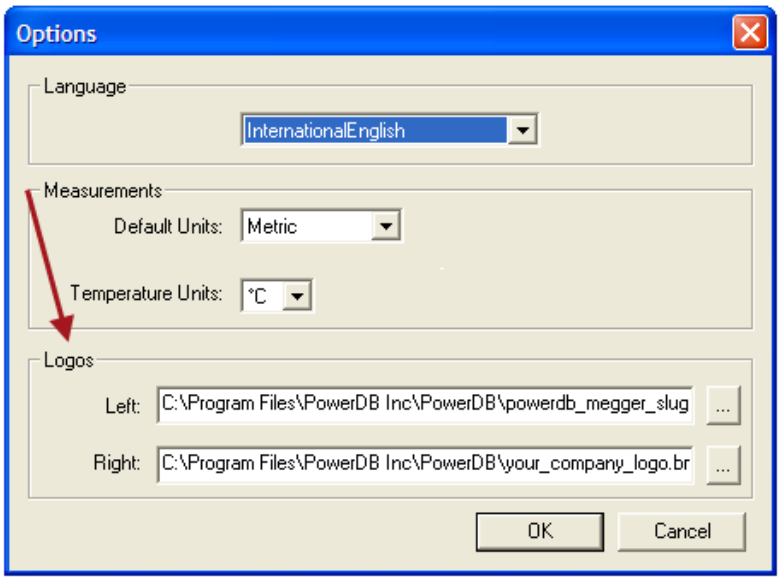
d. The Open screen allows you to browse to a file location, select a .JPG or .BMP file, and press the Open button.

e. Repeat steps (c) and (d) for the right logo path.

f. Note that a logo will not be shown if the logo file path is blank or the file does not exist.

g. Note after specifying the logo files the image will not be shown until the next time a form is opened (File>Open, or the File>New menu items).

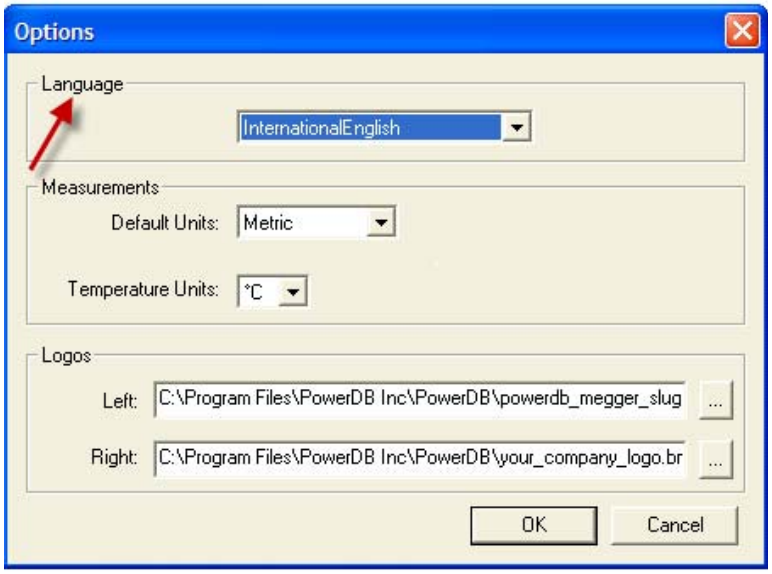
h. Note that the logos will look the best if the resolution of the file is 400 pixels wide by 240 pixels high. DPI is not important.



9. Change language and units

a. Select the Tools>Options menu item.

b. Select the appropriate language in the dropdown menu.



8

PowerDB Test Forms

General

Input fields

There are a number of input fields in the various forms. Some are text e.g. site information, others are drop down lists where only the selected values are valid.

To move between input fields you can use "Tab", "Enter" and/or arrow buttons or use a mouse/pointer. If you have a computer with touch screen you may just point at the field. Use keyboard for input values.

Transformer Configuration

Selecting Tests

Most forms have a variable complexity. When the form is opened a typical selection of standard tests are presented. By activating or deactivating the test checkboxes the form can be expanded or reduced.

Measurement Frequency

Single Frequency Tests

Measurement frequency is normally the same frequency as the power system e.g. 50 Hz in Europe and 60 Hz in USA. Select the default frequency in the Power DB settings pop-up screen.

Frequency Sweep

Delta4000 can also measure multiple frequencies in a "frequency sweep". Individual frequencies are defined in a list in PDB settings. The maximum frequency range is pending the test voltage as described in the following table.

Test Voltage	Maximum frequency range
12 kV	45-70 Hz
4 kV	15-405 Hz
2 kV	8-505 Hz
1 kV	4-505 Hz
500 V	2-505 Hz
250 V	1-505 Hz

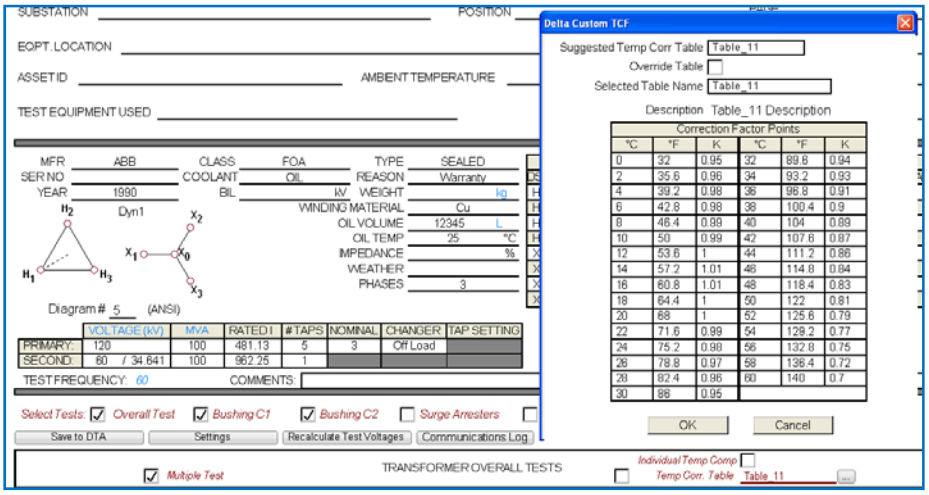
Note: *Do not select the power frequency or any multiple of power frequency in a frequency sweep, e.g. in 50 Hz networks avoid, 50, 100, 150… and in 60 Hz networks avoid 60, 120, 180…*

Temperature Correction

Delta4000 offers two temperature correction methods;

Standard Temperature Correction Tables

This is the standard correction method based on tables for various components. For power transformers the table selection is based on manufacturing year, transformer type (sealed, free breathing etc), voltage and power rating. For bushings the table is selected by manufacturer and type.



Intelligent Temperature Correction, ITC

As a unique feature Delta4000 also offers ITC, Intelligent Temperature Correction. With ITC the actual temperature correction for a certain measurement object is estimated by measuring an additional frequency sweep after performing the standard single frequency measurement. The information from the sweep test is then used to estimate the correct temperature correction from measurement temperature to 20°C reference (patent pending).

Note:	*Temperature range for ITC is 5-50° measurement/insulation temperature. The frequency range for performing ITC should be 2-500 Hz. Selecting a higher low frequency will limit the temperature range.*

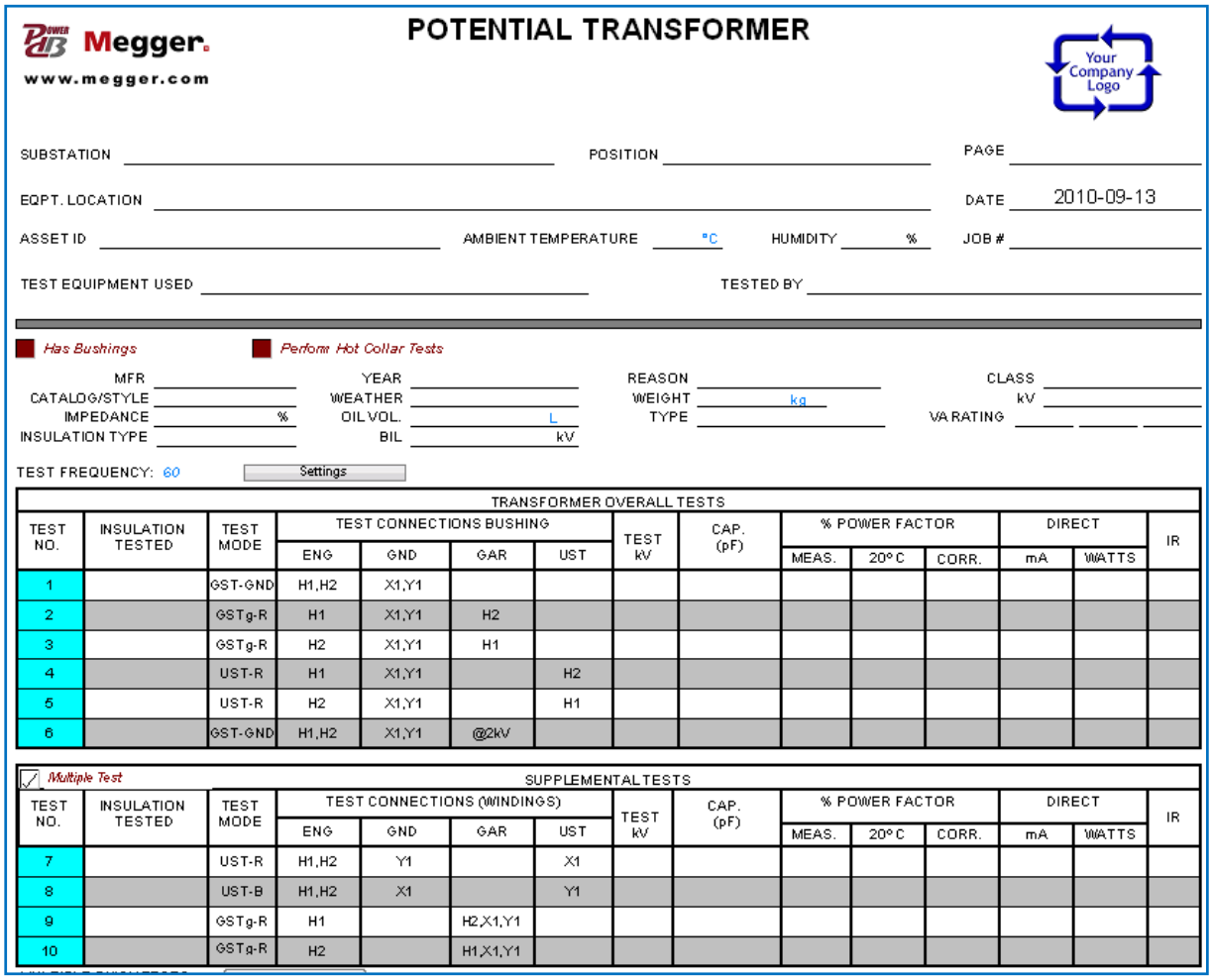
Voltage Dependence Detection

Another unique feature in Delta 4000 is automatic Voltage Dependence Detection (patent pending). In every test, Delta4000 measures the harmonic content of the signal and based on this information it calculates a Voltage Dependence Factor, VDF. If this value is too high (default > 0.05) the number turns red, indicating a voltage dependence of the test object i.e. the dissipation factor is pending the test voltage. In this situation a tip-up (step voltage) test should be performed to verify and quantify the voltage dependence.

BUSHING C1 TESTS — Individual Temp Comp ☐

TEST NO.		BUSHING NAMEPLATE				TEST MODE	TEST kV	Freq Sweep	CAPACITANCE C (pF)	POWER FACTOR %			DIRECT		%VDF
		DSG	SERIAL #	POWER FACTOR	CAPACITANCE					MEASURED	@ 20°C	CORR FACTOR	mA	WATTS	
HI KV	11	H1				UST-R	10.00	☐	159.43	0.30			0.5005	0.0148	0.025
	12	H2				UST-R	10.00	☐	159.90	0.43			0.5020	0.0216	0.054
	13	H3				UST-R	10.00	☐	159.83	0.29	0.28	0.953	0.5018	0.0147	0.026
	14	H0				UST-R	10.00	☐							

27600 – Potential Transformer



POTENTIAL TRANSFORMER

Megger.
www.megger.com

Your Company Logo

SUBSTATION _____ POSITION _____ PAGE _____

EQPT. LOCATION _____ DATE 2010-09-13

ASSET ID _____ AMBIENT TEMPERATURE _____ °C HUMIDITY _____ % JOB # _____

TEST EQUIPMENT USED _____ TESTED BY _____

Has Bushings Perform Hot Collar Tests

MFR _____ YEAR _____ REASON _____ CLASS _____
CATALOG/STYLE _____ WEATHER _____ WEIGHT _____ kg kV _____
IMPEDANCE _____ % OIL VOL. _____ L TYPE _____ VA RATING _____
INSULATION TYPE _____ BIL _____ kV

TEST FREQUENCY: 60 Settings

TRANSFORMER OVERALL TESTS

TEST NO.	INSULATION TESTED	TEST MODE	TEST CONNECTIONS BUSHING				TEST kV	CAP. (pF)	% POWER FACTOR			DIRECT		IR
			ENG	GND	GAR	UST			MEAS.	20°C	CORR.	mA	WATTS	
1		GST-GND	H1,H2	X1,Y1										
2		GSTg-R	H1	X1,Y1	H2									
3		GSTg-R	H2	X1,Y1	H1									
4		UST-R	H1	X1,Y1		H2								
5		UST-R	H2	X1,Y1		H1								
6		GST-GND	H1,H2	X1,Y1	@2kV									

Multiple Test

SUPPLEMENTAL TESTS

TEST NO.	INSULATION TESTED	TEST MODE	TEST CONNECTIONS (WINDINGS)				TEST kV	CAP. (pF)	% POWER FACTOR			DIRECT		IR
			ENG	GND	GAR	UST			MEAS.	20°C	CORR.	mA	WATTS	
7		UST-R	H1,H2	Y1		X1								
8		UST-B	H1,H2	X1		Y1								
9		GSTg-R	H1		H2,X1,Y1									
10		GSTg-R	H2		H1,X1,Y1									

Basic Form Information

The PF Potential Transformer form is used for power/dissipation factor testing high voltage potential transformers, those generally rated over 5kV. Nameplate information (serial number, ratings, etc.) should be entered which identifies the asset being tested, and general information regarding the test conditions (test date, weather conditions, etc.) should also be noted.

Labeling of windings and bushings vary from country to country and may also vary within a country based on manufacturing year and more. All description uses labeling H1, H2, H3, H0 for High side bushings. Equivalent labeling used are e.g. 1U, 1V, 1W, 1N or A, B, C, N. Corresponding labeling for other windings are e.g. X1, X2, X3, X0; 1U, 2V, 2W, 2N; a, b, c, n respectively Y1, Y2, Y3, Y0, 3U, 3V, 3W, 3N.

Testing

When testing is ready to be performed, the test can be started by;

Right-click the desired blue highlighted test number

or press F2 when the actual test row is activated (highlighted in yellow)

or for Delta4310 press the "Test" button when the actual test row is activated

and click "Start" on the pop-up screen or press enter key to start generating the test voltage.

The proper connections for the programmed tests are described below.

Bushing tests will only be performed on PT bushings that have test taps, usually those rated 15kV and above. Hot collar tests are generally performed on HV bushings that do not have test taps.

Transformer Overall Tests

Test 1 - This is a measurement of the overall insulation test on the PT primary winding. Short H1 and H2 together and connect HV cable. Short secondary windings X and Y together and connect Red or Blue lead. Test mode is GST-GND.

Test 2 - Cross check test on the primary overall insulation. Remove shorting lead on the primary winding. Connect HV cable to H1, Red lead to H2, and Blue lead to X/Y. Test mode is GSTg-R.

Test 3 - Cross check test on the primary overall insulation. Connect HV cable to H2, Red lead to H1, and Blue lead to X/Y. Test mode is GSTg-R.

NOTE	*Results of Test 2 added to Test 3 should be very close to Test 1 for Capacitance, Current, and Watts.*

Test 4 - Excitation current test of PT primary winding. Remove shorting leads from all windings. Connect HV cable to H1, Red lead to H2, and connect one end of each low voltage winding to ground. Test mode is UST-R.

Test 5 - Excitation current test of PT primary winding. Remove shorting leads from all windings. Connect HV cable to H2, Red lead to H1, and connect one end of each low voltage winding to ground. Test mode is UST-R.

NOTE:	*Test 4 and Test 5 duplicate the same test so results should be identical.*

Test 6 - This is a repeat of Test 1 (same connections) only performed at 2kV (if Test 1 was performed at 10kV).

Supplemental Tests

Test 7 - This tests the inter-winding insulation between primary (H) and secondary (X). Short H1 to H2 and short X and Y windings to themselves. Connect HV cable to H, Red lead to X and Blue lead to Y. Test mode is UST-R.

Test 8 - This tests the inter-winding insulation between primary (H) and secondary (Y). Short H1 to H2 and short X and Y windings to themselves. Connect HV cable to H, Red lead to X and Blue lead to Y. Test mode is UST-B.

Test 9 - This is a cross check test. Remove shorting lead from H1/H2. Connect HV lead to H1. Short X and Y windings together and connect to H2. Connect Red lead to H2. Test mode is Test mode is GSTg-R.

Test 10 - This is a cross check test. Remove shorting lead from H1/H2. Connect HV lead to H2. Short X and Y windings together and connect to H1. Connect Red lead to H1. Test mode is Test mode is GSTg-R.

Bushing Tests

Test 11 - This is the test of the C1 insulation on the H1 bushing (only performed if the bushing has a capacitance tap). All shorting leads must be removed. HV lead is connected to H1 and Red lead is connected to the test tap. Test mode is UST-R.

Test 12 - This is the test of the C1 insulation on the H2 bushing (only performed if the bushing has a capacitance tap). All shorting leads must be removed. HV lead is connected to H2 and Red lead is connected to the test tap. Test mode is UST-R.

CAUTION

Bushing test taps have very limited insulation and should generally be energized at reduced voltage levels. If the PT or bushing manufacturer does not specify a test voltage level use no more than 500 volts (0.5kV).

Test 13 - This is the test of the C2 insulation on the H1 bushing (only performed if the bushing has a capacitance tap). All shorting leads must be removed. HV lead is connected to the test tap and Red lead is connected to the H1 bushing. Test mode is GSTg-R.

Test 14 - This is the test of the C2 insulation on the H2 bushing (only performed if the bushing has a capacitance tap). All shorting leads must be removed. HV lead is connected to the test tap and Red lead is connected to the H2 bushing. Test mode is GSTg-R.

Bushing Hot Collar

Tests 15 to 26 - These tests measure the outer shell insulation of the bushings, including surface leakage and leakage current from the bushing surface through the insulating material to the center conductor. A conductive strap is placed around the bushing, below one of the skirts and connected to the HV lead. The Red lead is connected to the bushing conductor. Test mode is GST-GND.

Multiple hot collar tests can be performed on each bushing. For each test, the location of the strap should be clearly indicated on the form.

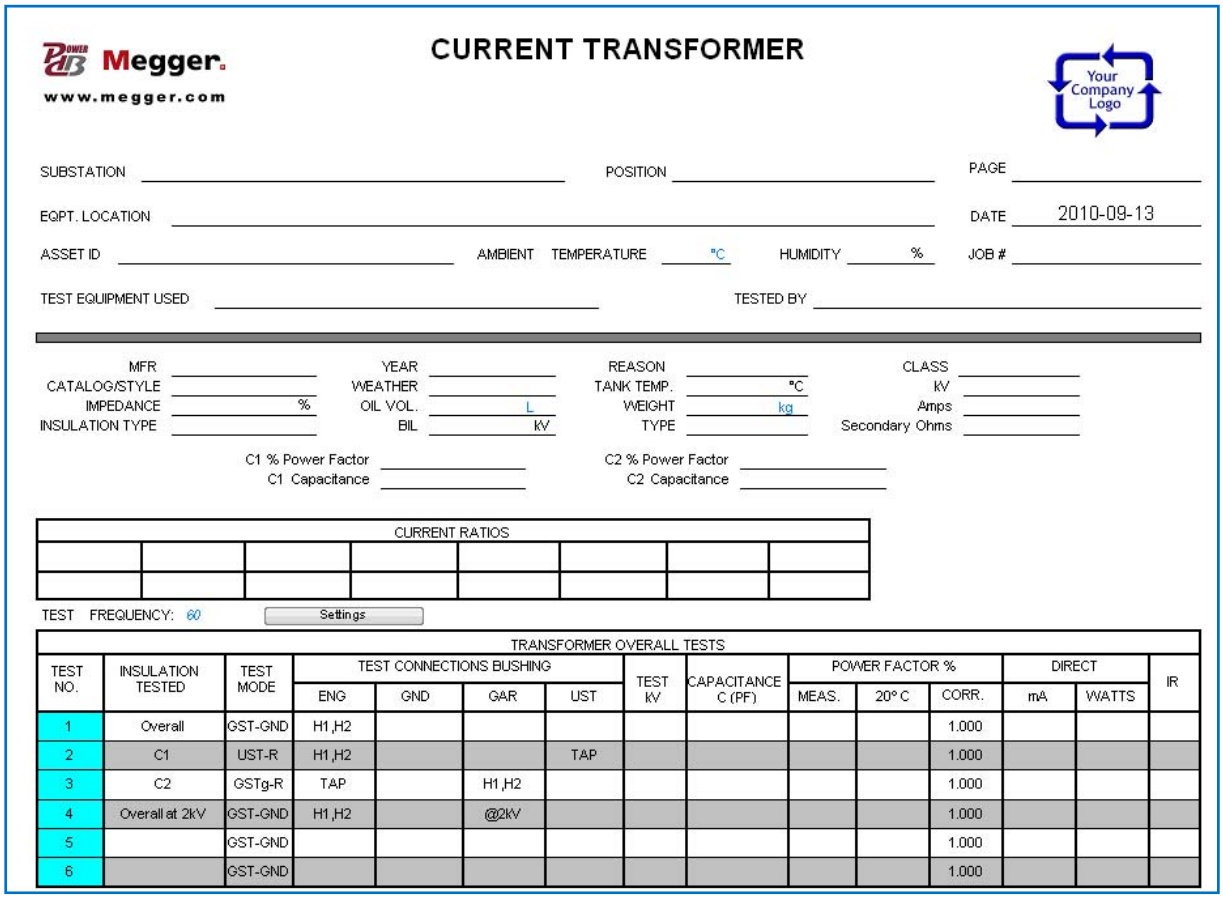
Multiple Quick Tests

Standards measurements may be complemented with additional measurements executed from the Multiple Quick Test sub-form selected as a new test or as manual measurements in the standard test forms. Check "Manual" in the select test boxes and a Multiple Quick Test table will be added at the end of the form.

In the field "INSULATION TESTED" you enter information on what to be tested, TEST MODE set/change the test mode, SUPPRESS set/change noise suppression mode.

It is also possible to use Delta Control for controlling the test by clicking the Delta Control button (above the table) in PowerDB form, Delta Control will send all data to be stored in the Multiple Quick Test table.

27610 – Current Transformer



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CURRENT TRANSFORMER

Your Company Logo

SUBSTATION _____ POSITION _____ PAGE _____

EQPT. LOCATION _____ DATE 2010-09-13

ASSET ID _____ AMBIENT TEMPERATURE ____ °C HUMIDITY ____ % JOB # _____

TEST EQUIPMENT USED _____ TESTED BY _____

MFR		YEAR		REASON		CLASS	
CATALOG/STYLE		WEATHER		TANK TEMP.	°C	kV	
IMPEDANCE	%	OIL VOL.	L	WEIGHT	kg	Amps	
INSULATION TYPE		BIL	kV	TYPE		Secondary Ohms	

C1 % Power Factor _____ C2 % Power Factor _____
C1 Capacitance _____ C2 Capacitance _____

CURRENT RATIOS							

TEST FREQUENCY: 60 Settings

TRANSFORMER OVERALL TESTS														
TEST NO.	INSULATION TESTED	TEST MODE	TEST CONNECTIONS BUSHING				TEST kV	CAPACITANCE C (PF)	POWER FACTOR %			DIRECT		IR
			ENG	GND	GAR	UST			MEAS.	20° C	CORR.	mA	WATTS	
1	Overall	GST-GND	H1,H2								1.000			
2	C1	UST-R	H1,H2			TAP					1.000			
3	C2	GSTg-R	TAP		H1,H2						1.000			
4	Overall at 2kV	GST-GND	H1,H2		@2kV						1.000			
5		GST-GND									1.000			
6		GST-GND									1.000			

Basic Form Information

The PF Current Transformer form is used for power/dissipation factor testing high voltage current transformers, those generally rated over 5kV. Power factor testing is normally not conducted on doughnut style current transformers.

Nameplate information (serial number, ratings, etc.) should be entered which identifies the asset being tested, and general information regarding the test conditions (test date, weather conditions, etc.) should also be noted.

Labeling of windings and bushings vary from country to country and may also vary within a country based on manufacturing year and more. All description uses labeling H1, H2, H3, H0 for High side bushings. Equivalent labeling used are e.g. 1U, 1V, 1W, 1N or A, B, C, N. Corresponding labeling for other windings are e.g. X1, X2, X3, X0; 1U, 2V, 2W, 2N; a, b, c, n respectively Y1, Y2, Y3, Y0, 3U, 3V, 3W, 3N.

Testing

When testing is ready to be performed, the test can be started by;

- Right-click the desired blue highlighted test number
- or press F2 when the actual test row is activated (highlighted in yellow)
- or for Delta4310 press the "Test" button when actual test row is activated

and click "Start" on the pop-up screen or press enter key to start generating the test voltage.

The proper connections for the programmed tests are described below.

Bushing tests will only be performed on CT bushings that have test taps, usually those rated 15kV and above. Hot collar tests are generally performed on HV bushings that do not have test taps.

Transformer Overall Tests

Test 1 - This is a measurement of the overall insulation test on the CT primary winding. Short H1 and H2 together and connect HV cable. Short secondary winding X together and connect to Ground. Test mode is GST-GND.

Test 2 - This is a measurement of the C1 insulation of the CT. This test is only performed if the CT main bushing has a capacitance or test tap. The HV cable remains connected to the H winding (which can remain shorted together) and the LV Red lead is connected to the test tap. Test mode is UST-R.

Test 3 - This is a measurement of the C2 insulation of the CT. This test is only performed if the CT main bushing has a capacitance or test tap. The HV cable is connected to the test tap and the LV Red lead is connected to the H winding (which can remain shorted together). Test mode is GSTg-R.

CAUTION

Bushing test taps have very limited insulation and should generally be energized at reduced voltage levels. If the CT or bushing manufacturer does not specify a test voltage level use no more than 500 volts (0.5kV) for test 3.

Test 4 - This is a repeat of Test 1 (same connections) only performed at 2kV (if Test 1 was performed at 10kV).

Test 5 - This test is available as a Miscellaneous Test that can be performed on the primary (H) winding of the CT for further investigation of unusual readings, if necessary. The test mode is GST-GND.

Test 6 - This test is available as a Miscellaneous Test that can be performed on the primary (H) winding of the CT for further investigation of unusual readings, if necessary. The test mode is GST-GND.

Hot Collar Tests

12 test lines are provided on this form for Hot Collar Tests on the primary bushing(s), if desired.

These tests measure the outer shell insulation of the bushings, including surface leakage and leakage current from the bushing surface through the insulating material to the center conductor. A conductive strap is placed around the bushing, below one of the skirts and connected to the HV lead. The Red lead is connected to the bushing conductor. Test mode is GST-GND.

Multiple hot collar tests can be performed on each bushing. For each test, the location of the strap should be clearly indicated on the form.

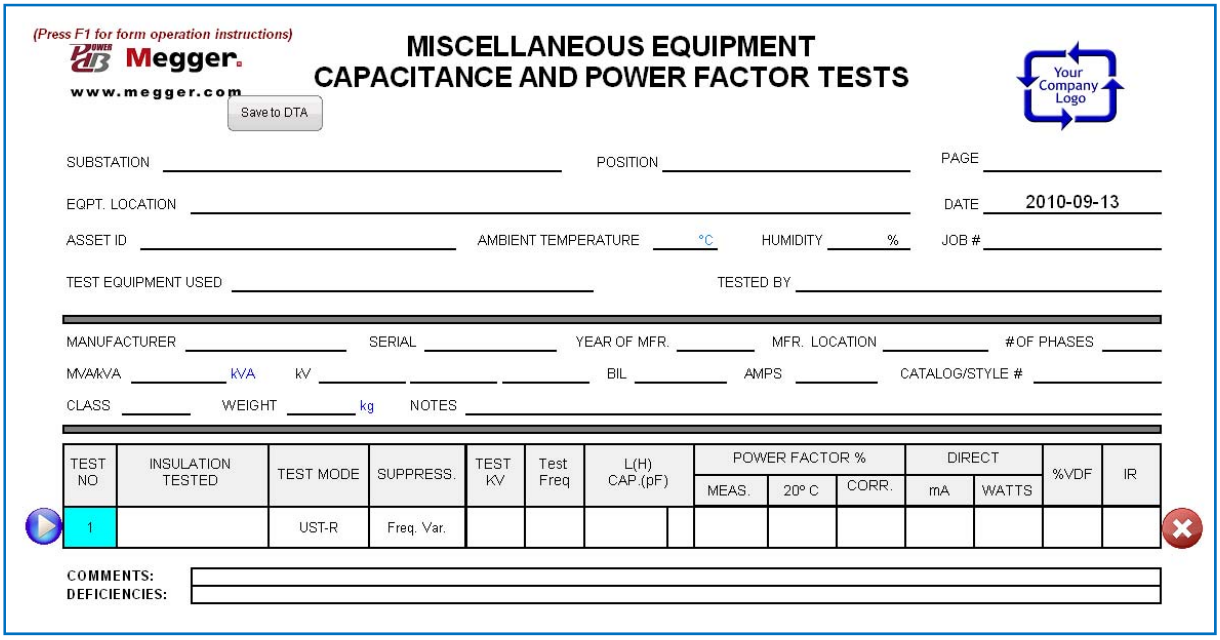
Multiple Quick Tests

Standards measurements may be complemented with additional measurements executed from the Multiple Quick Test sub-form selected as a new test or as manual measurements in the standard test forms. Check "Manual" in the select test boxes and a Multiple Quick Test table will be added at the end of the form.

In the field "INSULATION TESTED" you enter information on what to be tested, TEST MODE set/change the test mode, SUPPRESS set/change noise suppression mode.

It is also possible to use Delta Control for controlling the test by clicking the Delta Control button (above the table) in PowerDB form, Delta Control will send all data to be stored in the Multiple Quick Test table.

91510 – Miscellaneous Equipment



Basic Form Information

The PF Miscellaneous Equipment form is used for power factor/dissipation factor testing any type of electrical equipment, especially those types where a specific test form is not available. It allows flexibility in the number of tests that are performed, as well as allowing the user to select the specific test mode necessary for any testing situation.

Examples of the type of equipment testing that can be documented on this form include:

- Spare bushings
- High voltage insulators
- Lightning arresters
- Coupling capacitors (CCVT)
- Oil samples

In using the Miscellaneous Equipment form, the user accepts the responsibility of knowing how to properly connect and test the chosen piece of electrical equipment.

Apparatus nameplate information (serial number, ratings, etc.) may be documented to identify the asset being tested, and general information regarding the test conditions (test date, weather conditions, etc.) should also be noted. Liberal use of the COMMENTS field at the bottom of the form is recommended for documenting this information.

Description of Tests

Once the equipment to be tested has been properly connected to the HV lead, LV measuring leads and ground, the desired test mode must be selected before proceeding. The field "INSULATION TESTED" you enter information what to be tested, TEST MODE set the test mode, SUPPRESS set Suppression on/off (D2000/D3000) or if method select method Line Sync (Line Sync Polarity Reversal) or Freq. Var. (Frequency Variation) method should be used in Delta 4000

Measurements may be executed from the Multiple Quick Test sub-form or from Delta Control (Delta Control, only Delta 4000). If Delta Control is opened from the Delta Control button in PowerDB form, Delta Control will send all data to be stored in the Multiple Quick Test Sub-form.

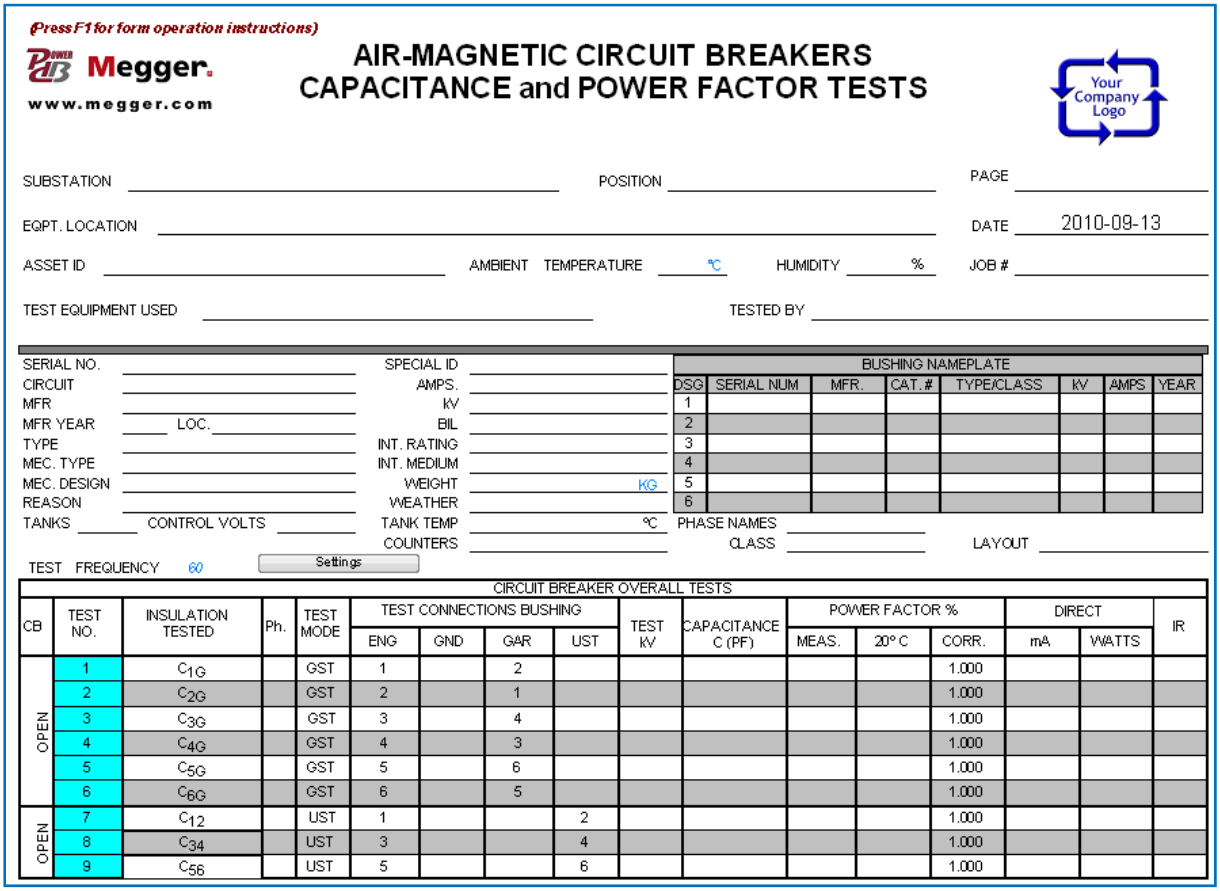
Once the desired test mode is chosen, the test sequence is initiated by;

- Right-click on the desired blue highlighted test number
- or press F2 when the actual test row is activated (highlighted in yellow)
- or for Delta4310 press the “Start” button when actual test row is activated

and click “Start” or “enter” on the pop-up screen to start generating the test voltage.

The test set will perform the selected test and place the results into the proper fields for that test line. As additional tests are desired and setup, the test table will grow to accommodate them.

92500 - Air-Magnetic Circuit Breaker form



(Press F1 for form operation instructions)

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AIR-MAGNETIC CIRCUIT BREAKERS
CAPACITANCE and POWER FACTOR TESTS

Your Company Logo

SUBSTATION _____ POSITION _____ PAGE _____

EQPT. LOCATION _____ DATE 2010-09-13

ASSET ID _____ AMBIENT TEMPERATURE _____ °C HUMIDITY _____ % JOB # _____

TEST EQUIPMENT USED _____ TESTED BY _____

SERIAL NO. _____ SPECIAL ID _____
CIRCUIT _____ AMPS. _____
MFR _____ kV _____
MFR YEAR _____ LOC. _____ BIL _____
TYPE _____ INT. RATING _____
MEC. TYPE _____ INT. MEDIUM _____
MEC. DESIGN _____ WEIGHT _____ KG
REASON _____ WEATHER _____
TANKS _____ CONTROL VOLTS _____ TANK TEMP _____ °C
COUNTERS _____

PHASE NAMES _____
CLASS _____
LAYOUT _____

TEST FREQUENCY 60 Settings

BUSHING NAMEPLATE

DSG	SERIAL NUM	MFR.	CAT. #	TYPE/CLASS	kV	AMPS	YEAR
1							
2							
3							
4							
5							
6							

CIRCUIT BREAKER OVERALL TESTS

CB	TEST NO.	INSULATION TESTED	Ph.	TEST MODE	TEST CONNECTIONS BUSHING				TEST kV	CAPACITANCE C (PF)	POWER FACTOR %			DIRECT		IR
					ENG	GND	GAR	UST			MEAS.	20° C	CORR.	mA	WATTS	
OPEN	1	C_{1G}		GST	1		2						1.000			
	2	C_{2G}		GST	2		1						1.000			
	3	C_{3G}		GST	3		4						1.000			
	4	C_{4G}		GST	4		3						1.000			
	5	C_{5G}		GST	5		6						1.000			
	6	C_{6G}		GST	6		5						1.000			
OPEN	7	C_{12}		UST	1			2					1.000			
	8	C_{34}		UST	3			4					1.000			
	9	C_{56}		UST	5			6					1.000			

Basic Form Information

The PF Air-Magnetic Circuit Breaker form is used for power factor testing medium voltage air magnetic circuit breakers. These are normally encountered in 5kV and 15kV switchgear.

Test modes are mentioned in the description of tests below. However, the test form is pre-programmed with the appropriate test modes to automatically be performed.

Description of Tets

Circuit Breaker Overall Tests

Prior to the overall insulation tests, remove the breaker from its cubicle or cell. Tests may be performed either with or without arc chutes installed. This should be noted in the Comments field for future reference.

The breaker will remain in the open position for all tests.

Tests 1 to 6 (C_{1G}, C_{2G}, C_{3G}, C_{4G}, C_{5G}, C_{6G}) - These are measurements of the ground insulation of each pole of the breaker with the breaker in the open position. Test 1 is indicated by Insulation Tested C_{1G}, Test 2 by Insulation Tested C_{2G}, etc. The HV cable is connected to each pole, in turn, with all other poles floating (no connection). The breaker frame must be connected to station ground. Test mode is GST-GND.

Test 7 (C_{12}) - This is a measurement of the insulation between the poles on Phase 1 or Phase A, and is indicated by Insulation Tested C_{12}. The HV cable is attached to Pole 1 and the LV Red lead is attached to Pole 2. All other breaker poles are left floating. This test is performed with the breaker open. Test mode is UST-R.

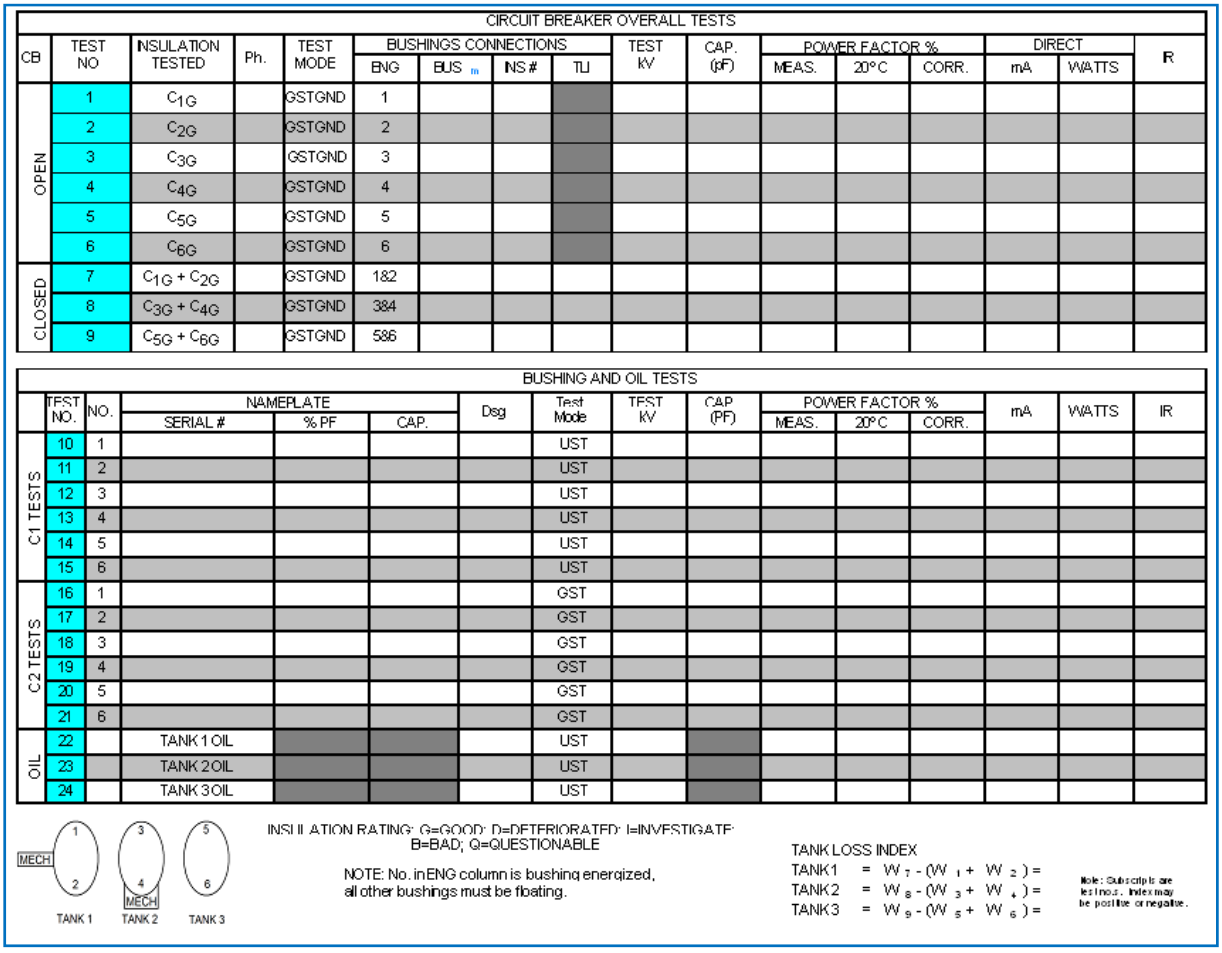
Test 8 (C_{34}) - This is a measurement of the insulation between the poles on Phase 2 or Phase B, and is indicated by Insulation Tested C_{34}. The HV cable is attached to Pole 3 and the LV Red lead is attached to Pole 4. All other breaker poles are left floating. This test is performed with the breaker open. Test mode is UST-R.

Test 9 (C_{56}) - This is a measurement of the insulation between the poles on Phase 3 or Phase C, and is indicated by Insulation Tested C_{56}. The HV cable is attached to Pole 5 and the LV Red lead is attached to Pole 6. All other breaker poles are left floating. This test is performed with the breaker open. Test mode is UST-R.

Diagnostic Tests

These tests provide flexibility for performing more diagnostic tests in the event that an area of concern presents itself. Each test line allows the operator to choose between test modes UST-R and/or GST-GND. A detailed description of the tests performed should be documented on the form, both in the Specimen/Connection field and the form Comments field.

92510 - Oil Circuit Breaker form



CIRCUIT BREAKER OVERALL TESTS

CB	TEST NO	INSULATION TESTED	Ph.	TEST MODE	BUSHINGS CONNECTIONS ENG	BUS m	INS #	TU	TEST kV	CAP. (pF)	POWER FACTOR % MEAS.	20°C	CORR.	DIRECT mA	WATTS	R
OPEN	1	C_{1G}		GSTGND	1											
	2	C_{2G}		GSTGND	2											
	3	C_{3G}		GSTGND	3											
	4	C_{4G}		GSTGND	4											
	5	C_{5G}		GSTGND	5											
	6	C_{6G}		GSTGND	6											
CLOSED	7	$C_{1G} + C_{2G}$		GSTGND	1&2											
	8	$C_{3G} + C_{4G}$		GSTGND	3&4											
	9	$C_{5G} + C_{6G}$		GSTGND	5&6											

BUSHING AND OIL TESTS

	TEST NO.	NO.	NAMEPLATE SERIAL #	% PF	CAP.	Dsg	Test Mode	TEST kV	CAP (PF)	POWER FACTOR % MEAS.	20°C	CORR.	mA	WATTS	IR
C1 TESTS	10	1					UST								
	11	2					UST								
	12	3					UST								
	13	4					UST								
	14	5					UST								
	15	6					UST								
C2 TESTS	16	1					GST								
	17	2					GST								
	18	3					GST								
	19	4					GST								
	20	5					GST								
	21	6					GST								
OIL	22		TANK 1 OIL				UST								
	23		TANK 2 OIL				UST								
	24		TANK 3 OIL				UST								

INSULATION RATING: G=GOOD; D=DETERIORATED; I=INVESTIGATE; B=BAD; Q=QUESTIONABLE

NOTE: No. in ENG column is bushing energized, all other bushings must be floating.

TANK LOSS INDEX

TANK1 = $W_7 - (W_1 + W_2) =$

TANK2 = $W_8 - (W_3 + W_4) =$

TANK3 = $W_9 - (W_5 + W_6) =$

Note: Subscripts are test nos.. Index may be positive or negative.

Basic Form Information

The PF Oil Circuit Breaker form is used for power factor testing medium and high voltage bulk oil circuit breakers. These are typically found in transmission and distribution substations.

Oil circuit breakers usually utilize condenser bushings with test taps which should be routinely tested whenever the overall insulation of the breaker is tested.

Test modes are mentioned in the description of tests below. However, the test form is pre-programmed with the appropriate test modes to automatically be performed.

Description of Tests

Circuit Breaker Overall Tests

Tests 1 to 6 are conducted with the circuit breaker in the open position. Tests 7 to 9 are conducted with the breaker in the closed position.

Tests 1 to 6 (C_{1G}, C_{2G}, C_{3G}, C_{4G}, C_{5G}, C_{6G}) - These are measurements of the ground insulation of each pole of the breaker with the breaker in the open position. Test 1 is indicated by Insulation Tested C_{1G}, Test 2 by Insulation Tested C_{2G}, etc. The HV cable is connected to each pole, in turn, with all other poles floating (no connection). The breaker frame must be connected to station ground. Test mode is GST-GND.

Test 7 ($C_{1G}+C_{2G}$) - This is a measurement of the insulation between Phase 1 (A) and ground, and is indicated by Insulation Tested $C_{1G}+C_{2G}$. This test is performed with the breaker closed. The HV cable is attached to either Pole 1 or Pole 2. All other breaker poles are left floating. Test mode is GST-GND.

Test 8 ($C_{3G}+C_{4G}$) - This is a measurement of the insulation between Phase 2 (B) and ground, and is indicated by Insulation Tested $C_{3G}+C_{4G}$. This test is performed with the breaker closed. The HV cable is attached to either Pole 3 or Pole 4. All other breaker poles are left floating. Test mode is GST-GND.

Test 9 ($C_{5G}+C_{6G}$) - This is a measurement of the insulation between Phase 3 (C) and ground, and is indicated by Insulation Tested $C_{5G}+C_{6G}$. This test is performed with the breaker closed. The HV cable is attached to either Pole 5 or Pole 6. All other breaker poles are left floating. Test mode is GST-GND.

Bushing and Oil Tests

Tests 10 to 15 - These are tests of the C1 insulation on the breaker bushings. The HV lead is connected to each bushing top terminal, in turn, and the LV Red lead is connected to the respective bushing test tap. Test mode is UST - MEAS RED, GND BLUE. At the completion of each test, the HV and Red leads are then moved to the next bushing to be tested.

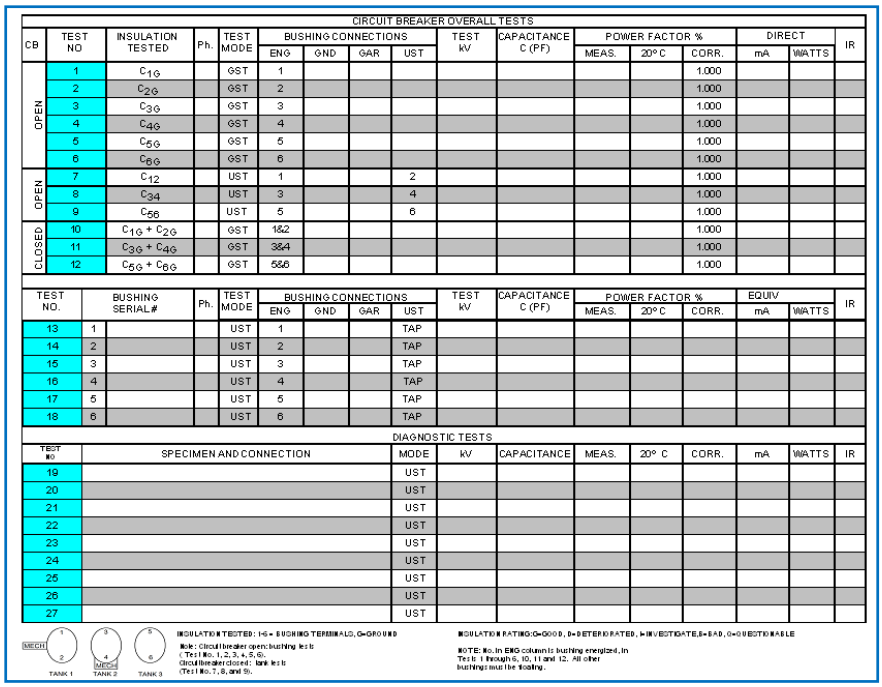
Tests 16 to 21 - These are tests of the C2 insulation on the breaker bushings. The LV Red lead is connected to each bushing top terminal, in turn, and the HV lead is connected to the respective bushing test tap. Test mode is GSTg-R. At the completion of each test, the HV and Red leads are then moved to the next bushing to be tested.

CAUTION

Bushing test taps have very limited insulation and should generally be energized at reduced voltage levels. If the bushing or breaker manufacturer does not specify a test voltage level use no more than 500 volts (0.5kV).

Tests 22 to 24 - These are tests of oil samples taken from each phase of the breaker (either 1 or 3). Each sample of oil is tested separately in an accessory oil test cell. Follow oil cell instructions for details on cell cleaning and filling. Record the temperature of the oil sample in the Nameplate section at the top of the form. Test mode is UST-R.

92520 - SF6 Dead Tank Circuit Breaker form



CIRCUIT BREAKER OVERALL TESTS

CB	TEST NO	INSULATION TESTED	Ph.	TEST MODE	BUSHING CONNECTIONS ENG	GND	GAR	UST	TEST kV	CAPACITANCE C (PF)	POWER FACTOR % MEAS.	20° C	CORR.	DIRECT mA	WATTS	IR
OPEN	1	C_{1G}		GST	1								1.000			
	2	C_{2G}		GST	2								1.000			
	3	C_{3G}		GST	3								1.000			
	4	C_{4G}		GST	4								1.000			
	5	C_{5G}		GST	5								1.000			
	6	C_{6G}		GST	6								1.000			
OPEN	7	C_{12}		UST	1			2					1.000			
	8	C_{34}		UST	3			4					1.000			
	9	C_{56}		UST	5			6					1.000			
CLOSED	10	$C_{1G} + C_{2G}$		GST	1&2								1.000			
	11	$C_{3G} + C_{4G}$		GST	3&4								1.000			
	12	$C_{5G} + C_{6G}$		GST	5&6								1.000			

TEST NO.	BUSHING SERIAL#		Ph.	TEST MODE	BUSHING CONNECTIONS ENG	GND	GAR	UST	TEST kV	CAPACITANCE C (PF)	POWER FACTOR % MEAS.	20° C	CORR.	EQUIV mA	WATTS	IR
13	1			UST	1			TAP								
14	2			UST	2			TAP								
15	3			UST	3			TAP								
16	4			UST	4			TAP								
17	5			UST	5			TAP								
18	6			UST	6			TAP								

DIAGNOSTIC TESTS

TEST NO	SPECIMEN AND CONNECTION	MODE	kV	CAPACITANCE	MEAS.	20° C	CORR.	mA	WATTS	IR
19		UST								
20		UST								
21		UST								
22		UST								
23		UST								
24		UST								
25		UST								
26		UST								
27		UST								

INSULATION TESTED: I=I + BUSHING TERMINALS, G=GROUND

Note: Circuit breaker open: bushing tests (Test No. 1, 2, 3, 4, 5, 6). Circuit breaker closed: tank tests (Test No. 7, 8, and 9).

INSULATION RATING: G=GOOD, D=DETERIORATED, I=INVESTIGATE, B=BAD, O=OBJECTIONABLE

NOTE: No. in ENG column is bushing energized, in Tests 1 through 6, 10, 11 and 12. All other bushings must be floating.

Basic Form Information

The PF SF6 Dead Tank Circuit Breaker form is used for power factor testing medium and high voltage SF6 circuit breakers. These are typically found in outdoor transmission and distribution substation applications. Dead tank circuit breakers are those whose high voltage interrupting chamber is housed in an earth grounded enclosure or tank.

SF6 dead tank circuit breakers occasionally utilize condenser bushings with test taps which should be routinely tested whenever the overall insulation of the breaker is tested. If so equipped, all bushing nameplate information should be documented on the test form.

Test modes are mentioned in the description of tests below. However, the test form is pre-programmed with the appropriate test modes to automatically be performed.

Description of Tests

Circuit Breaker Overall Tests

Test 1 (C_{1G}) - This is a measurement of the ground insulation on Pole 1 with the circuit breaker in the open position. All other poles on the breaker will be floating (no connection). The HV cable will be connected to the bushing top terminal. No LV lead connection is required. The frame of the breaker must be connected to station ground. Test mode is GST-GND.

Test 2 (C_{2G}) - This is a measurement of the ground insulation on Pole 2 with the circuit breaker in the open position. All other poles on the breaker will be floating (no connection). The HV cable will be connected to the bushing top terminal. No LV lead connection is required. The frame of the breaker must be connected to station ground. Test mode is GST-GND.

Test 3 (C_{3G}) - This is a measurement of the ground insulation on Pole 3 with the circuit breaker in the open position. All other poles on the breaker will be floating (no connection). The HV cable will be connected to the bushing top terminal. No LV lead connection is required. The frame of the breaker must be connected to station ground. Test mode is GST-GND.

Test 4 (C_{4G}) - This is a measurement of the ground insulation on Pole 4 with the circuit breaker in the open position. All other poles on the breaker will be floating (no connection). The HV cable will be connected to the bushing top terminal. No LV lead connection is required. The frame of the breaker must be connected to station ground. Test mode is GST-GND.

Test 5 (C_{5G}) - This is a measurement of the ground insulation on Pole 5 with the circuit breaker in the open position. All other poles on the breaker will be floating (no connection). The HV cable will be connected to the bushing top terminal. No LV lead connection is required. The frame of the breaker must be connected to station ground. Test mode is GST-GND.

Test 6 (C_{6G}) - This is a measurement of the ground insulation on Pole 6 with the circuit breaker in the open position. All other poles on the breaker will be floating (no connection). The HV cable will be connected to the bushing top terminal. No LV lead connection is required. The frame of the breaker must be connected to station ground. Test mode is GST-GND.

Test 7 (C_{12}) - This is a measurement of the insulation on Phase 1 (A) between Pole 1 and Pole 2 with the circuit breaker in the open position. All other poles on the breaker will be floating (no connection). The HV cable will be connected to the bushing top terminal of either Pole 1 or 2. The LV Red lead is connected to the other Pole. The frame of the breaker must be connected to station ground. Test mode is UST-R.

Test 8 (C_{34}) - This is a measurement of the insulation on Phase 2 (B) between Pole 3 and Pole 4 with the circuit breaker in the open position. All other poles on the breaker will be floating (no connection). The HV cable will be connected to the bushing top terminal of either Pole 3 or 4. The LV Red lead is connected to the other Pole. The frame of the breaker must be connected to station ground. Test mode is UST-R.

Test 9 (C_{56}) - This is a measurement of the insulation on Phase 3 (C) between Pole 5 and Pole 6 with the circuit breaker in the open position. All other poles on the breaker will be floating (no connection). The HV cable will be connected to the bushing top terminal of either Pole 5 or 6. The LV Red lead is connected to the other Pole. The frame of the breaker must be connected to station ground. Test mode is UST-R.

Test 10 (C_{1G}+ C_{2G}) - This is a measurement of the ground insulation on Phase 1 (A) with the circuit breaker in the closed position. All other phases on the breaker will be floating (no connection). The HV cable will be connected to the bushing top terminal of Pole 1 or 2. No LV lead connection is required. The frame of the breaker must be connected to station ground. Test mode is GST-GND.

Test 11 (C_{3G}+ C_{4G}) - This is a measurement of the ground insulation on Phase 2 (B) with the circuit breaker in the closed position. All other phases on the breaker will be floating (no connection). The HV cable will be connected to the bushing top terminal of Pole 3 or 4. No LV lead connection is required. The frame of the breaker must be connected to station ground. Test mode is GST-GND.

Test 12 (C_{5G}+ C_{6G}) - This is a measurement of the ground insulation on Phase 3 (C) with the circuit breaker in the closed position. All other phases on the breaker will be floating (no connection). The HV cable will be connected to the bushing top terminal of Pole 5 or 6. No LV lead connection is required. The frame of the breaker must be connected to station ground. Test mode is GST-GND.

Bushing Tests

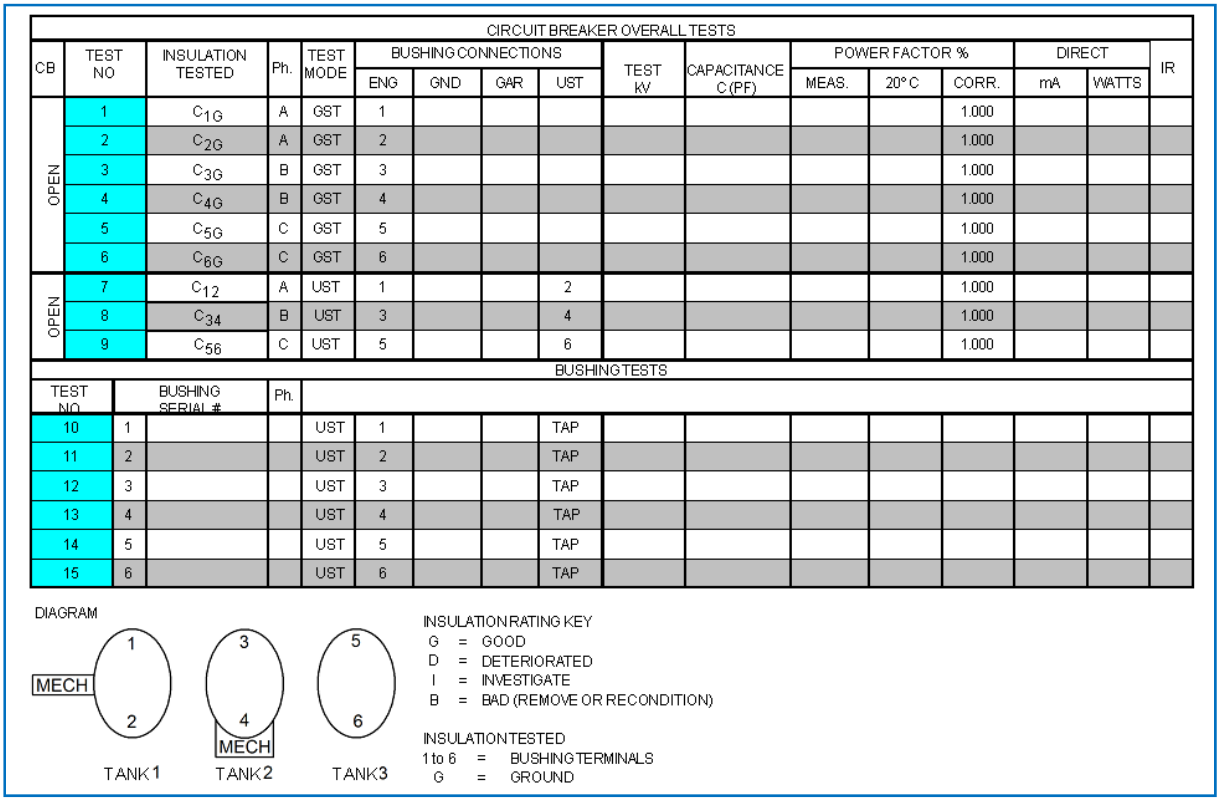
SF6 dead tank circuit breakers occasionally utilize condenser bushings with test taps which should be routinely tested whenever the overall insulation of the breaker is tested.

The table supplied may be used to measure the C1 insulation on condenser bushings, if so equipped. The HV lead is connected to each bushing top terminal, in turn, and the LV Red lead is connected to the respective bushing test tap. For all tests, test mode is UST-R. At the completion of each test, the HV and Red leads are then moved to the next bushing to be tested.

Diagnostic Tests

These tests provide flexibility for performing more diagnostic tests in the event that an area of concern presents itself. Each test line allows the operator to choose between test modes UST-R, and GST-GND. A detailed description of the tests performed should be documented on the form, both in the Specimen/Connection field and the form Comments field.

92530- Vacuum Circuit Breaker



CIRCUIT BREAKER OVERALL TESTS

CB	TEST NO	INSULATION TESTED	Ph.	TEST MODE	BUSHING CONNECTIONS ENG	GND	GAR	UST	TEST kV	CAPACITANCE C (PF)	POWER FACTOR % MEAS.	20°C	CORR.	DIRECT mA	WATTS	IR
OPEN	1	C_{1G}	A	GST	1								1.000			
	2	C_{2G}	A	GST	2								1.000			
	3	C_{3G}	B	GST	3								1.000			
	4	C_{4G}	B	GST	4								1.000			
	5	C_{5G}	C	GST	5								1.000			
	6	C_{6G}	C	GST	6								1.000			
OPEN	7	C_{12}	A	UST	1			2					1.000			
	8	C_{34}	B	UST	3			4					1.000			
	9	C_{56}	C	UST	5			6					1.000			

BUSHING TESTS

TEST NO	BUSHING SERIAL #	Ph.													
10	1			UST	1			TAP							
11	2			UST	2			TAP							
12	3			UST	3			TAP							
13	4			UST	4			TAP							
14	5			UST	5			TAP							
15	6			UST	6			TAP							

Basic Form Information

The PF Vacuum Circuit Breaker form is used for power factor testing medium and high voltage vacuum circuit breakers. These are normally encountered above 5kV in both switchgear and outdoor substation applications.

Test modes are mentioned in the description of tests below. However, the test form is pre-programmed with the appropriate test modes to automatically be performed.

Description of Tests

Circuit Breaker Overall Tests

Prior to the overall insulation tests, remove the breaker from its cubicle or cell, if applicable.

The breaker will remain in the open position for all tests.

Tests 1 to 6 (C_{1G}, C_{2G}, C_{3G}, C_{4G}, C_{5G}, C_{6G}) - These are measurements of the ground insulation of each pole of the breaker with the breaker in the open position. Test 1 is indicated by Insulation Tested C_{1G}, Test 2 by Insulation Tested C_{2G}, etc. The HV cable is connected to each pole, in turn, with all other poles floating (no connection). The breaker frame must be connected to station ground. Test mode is GST-GND.

Test 7 (C_{12}) - This is a measurement of the insulation between the poles on Phase 1 or Phase A, and is indicated by Insulation Tested C_{12}. The HV cable is attached to Pole 1 and the LV Red lead is attached to Pole 2. All other breaker poles are left floating. This test is performed with the breaker open. Test mode is UST-R.

Test 8 (C_{34}) - This is a measurement of the insulation between the poles on Phase 2 or Phase B, and is indicated by Insulation Tested C_{34}. The HV cable is attached to Pole 3 and the LV Red lead is attached to Pole 4. All other breaker poles are left floating. This test is performed with the breaker open. Test mode is UST-R.

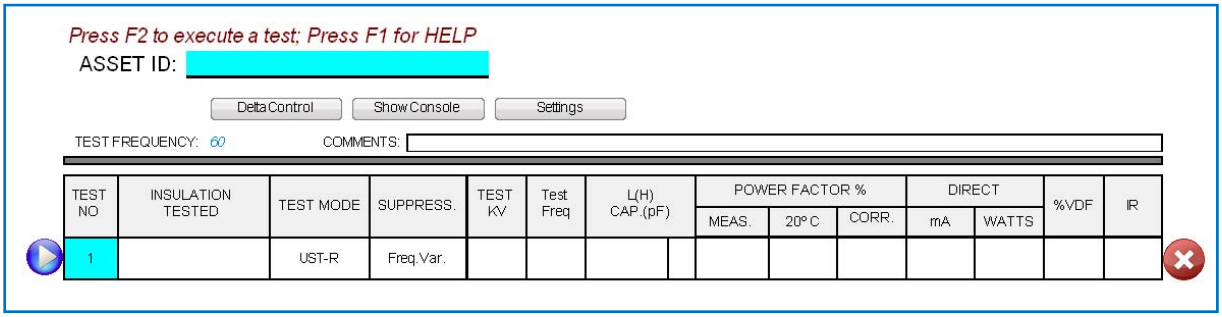
Test 9 (C_{56}) - This is a measurement of the insulation between the poles on Phase 3 or Phase C, and is indicated by Insulation Tested C_{56}. The HV cable is attached to Pole 5 and the LV Red lead is attached to Pole 6. All other breaker poles are left floating. This test is performed with the breaker open. Test mode is UST-R.

Bushing Tests

Most vacuum circuit breakers are not supplied with condenser bushings, except for those rated above 15kV.

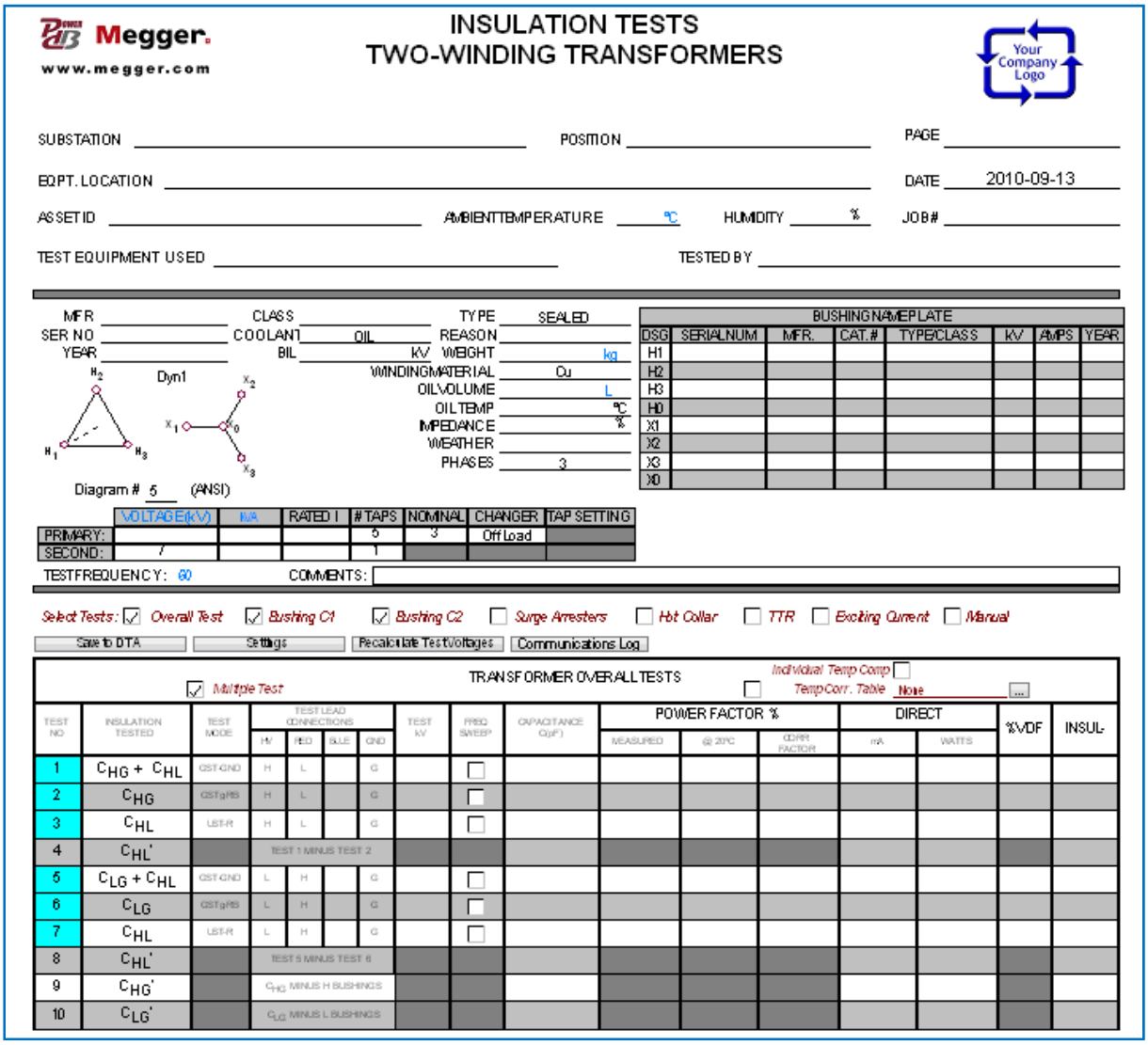
The table supplied may be used to measure the C1 insulation on condenser bushings, if so equipped. For all tests, test mode is UST-R.

93002 – Multiple Dissipation/Power Factor Quick Test



- Enter the Asset ID
- Enter the temperature correction factor (TCF). If you do not know or want to correct for temperature please leave this value at 1
- Enter the optional description
- Enter test voltage or run the test with Delta Control
- Start the test

93500 – Two-Winding Transformer



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INSULATION TESTS
TWO-WINDING TRANSFORMERS

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SUBSTATION _____ POSITION _____ PAGE _____

EQPT. LOCATION _____ DATE 2010-09-13

ASSET ID _____ AMBIENT TEMPERATURE _____ °C HUMIDITY _____ % JOB # _____

TEST EQUIPMENT USED _____ TESTED BY _____

MFR _____ CLASS _____ TYPE SEALED
SER NO _____ COOLANT OIL REASON _____
YEAR _____ BIL _____ kV WEIGHT _____ kg
WINDING MATERIAL Cu
OIL VOLUME _____ L
OIL TEMP _____ °C
IMPEDANCE _____ %
WEATHER _____
PHASES 3

Dyn1

Diagram # 5 (ANSI)

BUSHING NAMEPLATE

DSG	SERIAL NUM	MFR.	CAT. #	TYPE/CLASS	kV	AMPS	YEAR
H1							
H2							
H3							
H0							
X1							
X2							
X3							
X0							

	VOLTAGE (kV)	kVA	RATED I	# TAPS	NOMINAL	CHANGER	TAP SETTING
PRIMARY:				5	3	Off Load	
SECOND:	7			1			

TEST FREQUENCY: 60 COMMENTS: _____

Select Tests: ☑ Overall Test ☑ Bushing C1 ☑ Bushing C2 ☐ Surge Arresters ☐ Hot Collar ☐ TTR ☐ Exciting Current ☐ Manual

Save to DTA | Settings | Recalculate Test Voltages | Communications Log

☑ Multiple Test — TRANSFORMER OVERALL TESTS — ☐ Individual Temp Comp — ☐ Temp Corr. Table None

TEST NO	INSULATION TESTED	TEST MODE	TEST LEAD CONNECTIONS H/	RED	BLUE	GND	TEST kV	FREQ SWEEP	CAPACITANCE (pF)	POWER FACTOR % MEASURED	@ 20°C	CORR FACTOR	DIRECT mA	WATTS	%VDF	INSUL.
1	$C_{HG} + C_{HL}$	GST-GND	H	L		G		☐								
2	C_{HG}	GSTg-RS	H	L		G		☐								
3	C_{HL}	UST-R	H	L		G		☐								
4	C_{HL}'		TEST 1 MINUS TEST 2													
5	$C_{LG} + C_{HL}$	GST-GND	L	H		G		☐								
6	C_{LG}	GSTg-RS	L	H		G		☐								
7	C_{HL}	UST-R	L	H		G		☐								
8	C_{HL}'		TEST 5 MINUS TEST 6													
9	C_{HG}'		C_{HG} MINUS H BUSHINGS													
10	C_{LG}'		C_{LG} MINUS L BUSHINGS													

Basic Form Information

The PF Two-Winding Transformer form is used for power factor/dissipation factor testing medium and high voltage power transformers, generally those with at least one winding rated over 5kV.

Description of Tests

Transformer Overall Tests

Prior to the overall insulation tests, short all high side (H) bushings together and short all low side (L) bushings together, keeping both windings separated. Remove ground connections from neutral bushings.

Test 1 - This is a measurement of the insulation between the transformer high voltage winding and the transformer tank, plus the insulation between the high voltage winding and the low voltage winding, both measured in parallel. Connect the HV cable to the H winding and connect the Red lead to the X winding. Test mode is GST-GND.

Test 2 - This is a measurement of the insulation between the transformer high voltage winding and the transformer tank. Connections are exactly the same as for Test 1. Test mode is GSTg-RB.

Test 3 - This is a measurement of the insulation between the transformer high voltage winding and the low voltage winding. Connections are exactly the same as for Test 1 and 2. Test mode is UST-R.

NOTE:	*Once Tests 1, 2 and 3 are completed, Line 4 will populate with values calculated by subtracting Test 2 from Test 1. This is applicable for values of capacitance, current and watts. Line 4 is a calculated comparison to the direct measurements of Test 3. Values on these two lines should be essentially the same. If they are not, re-check all connections and verify the proper operation of the test set. If Test 3 and Line 4 vary by more than 2%, the Insulation Rating (IR) will automatically populate with B (Bad).*

Test 5 - This is a measurement of the insulation between the transformer low voltage winding and the transformer tank, plus the insulation between the low voltage winding and the high voltage winding, both measured in parallel. Connect the HV cable to the low side (L) winding and connect the Red lead to the H winding. Test mode is GST-GND.

Test 6 - This is a measurement of the insulation between the transformer low voltage winding and the transformer tank. Connections are exactly the same as for Test 5. Test mode is GSTg-RB.

Test 7 - This is a measurement of the insulation between the transformer low voltage winding and the high voltage winding. Connections are exactly the same as for Test 5 and 6. Test mode is UST-R.

NOTE:	*Once Tests 5, 6 and 7 are completed, Line 8 will populate with values calculated by subtracting Test 6 from Test 5. This is applicable for values of capacitance, current and watts. Line 8 is a calculated comparison to the direct measurements of Test 7. Values on these two lines should be essentially the same. If they are not, re-check all connections and verify the proper operation of the test set. If Test 7 and Line 8 vary by more than 2%, the Insulation Rating (IR) will automatically populate with B (Bad).*

Lines 9 and 10 will automatically populate with calculated values once Tests 1-7 and all bushing tests are completed. Line 9 is a corrected value for the insulation of the high voltage winding to the transformer tank minus the measured losses of the high side bushings. Line 10 is a corrected value for the insulation of the low voltage winding to the transformer tank minus the measured losses of the low side bushings.

Bushing C1 Tests

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BUSHING C1 TESTS — *Individual Temp Comp* ☐

TEST NO.		BUSHING NAMEPLATE				TEST MODE	TEST kV	Freq Sweep	CAPACITANCE C (pF)	POWER FACTOR %			DIRECT		%VDF	IR
		DSG	SERIAL#	POWER FACTOR	CAPACITANCE					MEASURED	@ 20°C	CORR FACTOR	mA	WATTS		
HI kV	11	H1				UST-R		☐								
	12	H2				UST-R		☐								
	13	H3				UST-R		☐								
	14	H0				UST-R		☐								
LOW kV	15	X1				UST-R		☐								
	16	X2				UST-R		☐								
	17	X3				UST-R		☐								
	18	X0				UST-R		☐								
	19	OIL TEST				UST-R		☐								

Show Sweep Results ☐

BUSHING C2 TESTS

TEST NO.		BUSHING NAMEPLATE				TEST MODE	TEST kV	Freq Sweep	CAPACITANCE C (pF)	POWER FACTOR %			DIRECT		%VDF	IR
		DSG	SERIAL#	POWER FACTOR	CAPACITANCE					MEASURED	@ 20°C	CORR FACTOR	mA	WATTS		
HI kV	20	H1				GSTg-R	0.50	☐								
	21	H2				GSTg-R	0.50	☐								
	22	H3				GSTg-R	0.50	☐								
	23	H0				GSTg-R	0.50	☐								
LOW kV	24	X1				GSTg-R	0.50	☐								
	25	X2				GSTg-R	0.50	☐								
	26	X3				GSTg-R	0.50	☐								
	27	X0				GSTg-R	0.50	☐								

If the transformer windings are terminated using condenser bushings, then measurements of the C1 insulation on each bushing are generally made. The bushing insulation C1 is internal and is the insulation between the bushing center

conductor and its test tap (capacitance tap). If a bushing does not have a test tap, then the C1 measurement is not performed.

NOTE:	*These tests may be performed with the bushing shorting leads still in place from the overall insulation tests. This allows all the high side bushing C1 tests to be performed without having to move the HV lead from bushing to bushing. It will still be necessary to move the Red lead to the individual test taps for each test.*

Test 11 - This is the test of the C1 insulation on the high side phase 1 bushing. The HV lead is connected to the bushing top terminal and the Red lead is connected to the bushing test tap. Test mode is UST-R.

Tests 12, 13 and 14 are C1 measurements for the other high side bushings. Test 14 is used only if the high winding has a neutral bushing with a test tap. Make sure to move the Red lead connection from bushing to bushing as necessary. Test mode is UST-R.

Tests 15, 16, 17, and 18 are C1 measurements for the low side (L) bushings. Test 18 is used only if the high winding has a neutral bushing with a test tap. Test mode is UST-R.

NOTE:	*Many condenser bushings will have factory values for C1 stamped on their nameplates, both for power factor and capacitance. The test results for C1 on each bushing can be compared directly to its respective nameplate values.*

Oil Tests

The 93500 test form includes a single test line (Test 19) for capturing the results of a power factor test on the insulating oil. This is generally done on a sample of oil drawn from the main tank of the transformer under test. The test requires an oil test cell designed for field use. The test cell should be a three-terminal cell where connections for high voltage, measurement lead, and ground can be safely made.

As with the other insulation tests on this test form, the test sequence is initiated by right-clicking on the blue highlighted test number (19) at the bottom of the Bushing C1 Tests table. The test mode used is UST-R.

Bushing C2 Tests

Bushings with test taps may also be tested to obtain a C2 insulation measurement. The C2 insulation is the insulation between the test tap connection and the bushing mounting flange. To perform a C2 test, the HV lead is carefully connected to the bushing test tap and the Red lead is connected to the bushing center conductor. Care should be taken not to cause physical damage to the test tap, as the tap connection point may be a small pin or a flexible spring. If this is the case, use a small insulated jumper wire or a specially designed test tap adapter to make the HV lead connection.

CAUTION

Bushing test taps have very limited insulation and should generally be energized at reduced voltage levels. If the bushing manufacturer does not specify a test voltage level use no more than 500 volts (0.5kV).

Tests 20 to 27 are measurements of the individual bushings C2 insulation. All are performed with test mode GSTg-R All phase and neutral bushings may be tested providing they have test taps.

NOTE: Similar to the bushing C1 tests, all the C2 measurements may be made with the bushing shorting leads still in place from the transformer overall tests.

Surge Arresters

SURGE ARRESTERS

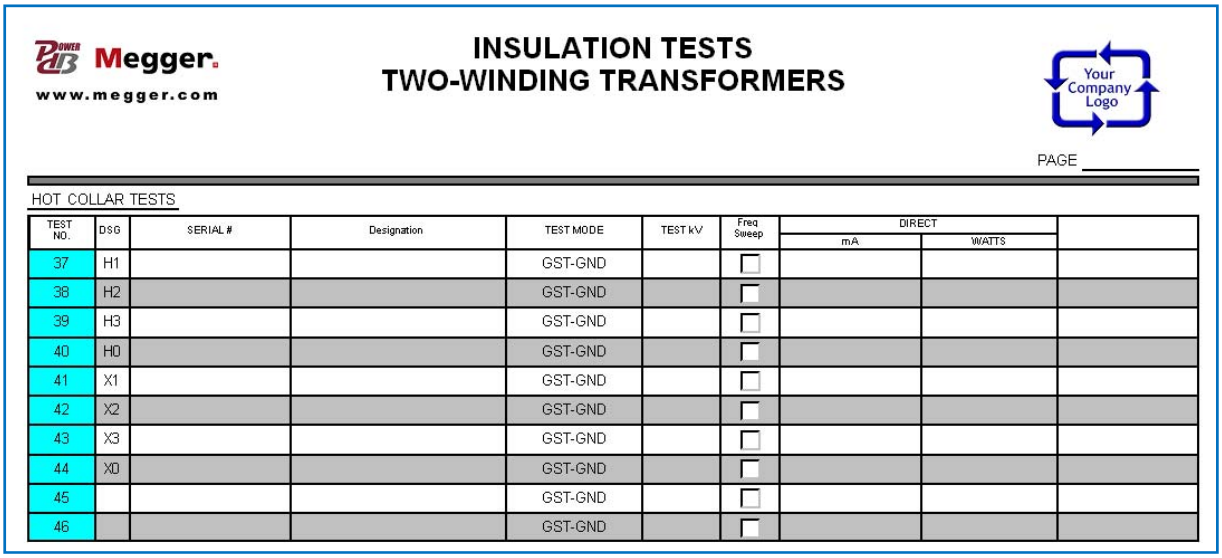
	LOCATION	SERIAL #	MFR	OVERALL CATALOG	UNIT CATALOG	TYPE	RATED kV	ORDER	TEST MODE	TEST kV	Freq Sweep	DIRECT		IR
												mA	WATTS	
28									GST-GND		☐			
29									GST-GND		☐			
30									GST-GND		☐			
31									GST-GND		☐			
32									GST-GND		☐			
33									GST-GND		☐			
34									GST-GND		☐			
35									GST-GND		☐			
36									GST-GND		☐			

If the transformer is equipped with surge or lightning arresters, these may be tested as well. If the arrester is a single-stack unit, its HV connection must be disconnected to eliminate the measurement of losses from other connected apparatus (such as switch and support insulators). Multi-stack arresters may be tested without disconnecting if desired. The procedure described below assumes single-stack arresters are being tested.

Nameplate, serial number and location information for each arrester should be entered so that future testing can be compared to specific units.

Tests 28 to 36 are measurements of the arrester insulation. Only test voltage, current and watts are recorded for arresters. The HV lead is attached to the arrester HV terminal. No connection using the Red or Blue leads is necessary. The Test Mode used is GST-GND. Once the HV lead is connected, right-click on the blue highlighted field on the desired test line to initiate the test sequence. Follow the onscreen instructions to complete the test.

Bushing Hot Collar Tests



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TWO-WINDING TRANSFORMERS

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HOT COLLAR TESTS

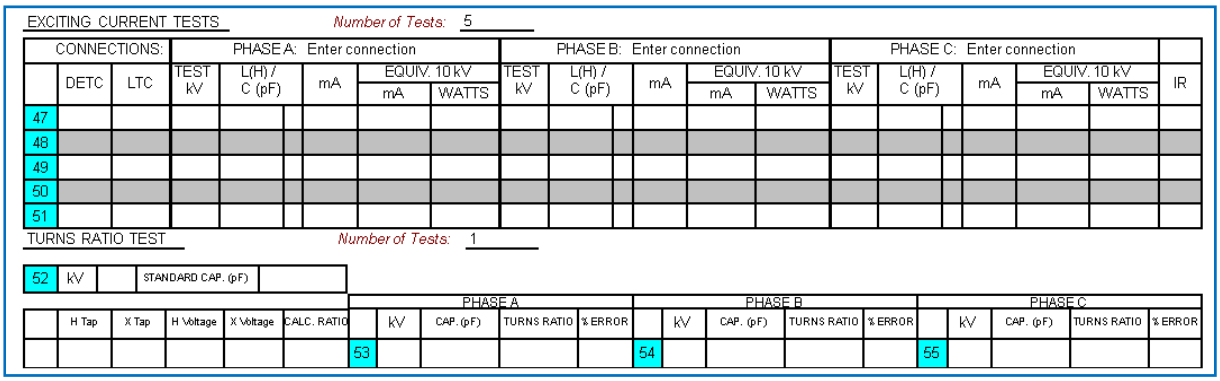
TEST NO.	DSG	SERIAL #	Designation	TEST MODE	TEST kV	Freq Sweep	DIRECT		
							mA	WATTS	
37	H1			GST-GND		☐			
38	H2			GST-GND		☐			
39	H3			GST-GND		☐			
40	H0			GST-GND		☐			
41	X1			GST-GND		☐			
42	X2			GST-GND		☐			
43	X3			GST-GND		☐			
44	X0			GST-GND		☐			
45				GST-GND		☐			
46				GST-GND		☐			

Hot collar tests are generally performed on HV bushings that do not have test taps. However, these tests may also be done as an additional test if the bushings have test taps

Tests 37 to 46 - These tests measure the outer shell insulation of the bushings, including surface leakage and leakage current from the bushing surface through the insulating material to the center conductor. A conductive strap is placed around the bushing, below one of the skirts, normally the top skirt, and connected to the HV lead. The Red lead is connected to the bushing conductor. Test mode GST-GND is automatically programmed by the test form.

Multiple hot collar tests can be performed on each bushing. For each test, the location of the strap should be clearly indicated on the form in the Designation column.

Exciting Current Tests



EXCITING CURRENT TESTS Number of Tests: 5

	CONNECTIONS:		PHASE A: Enter connection					PHASE B: Enter connection					PHASE C: Enter connection					
	DETC	LTC	TEST kV	L(H) / C (pF)	mA	EQUIV. 10 kV mA	EQUIV. 10 kV WATTS	TEST kV	L(H) / C (pF)	mA	EQUIV. 10 kV mA	EQUIV. 10 kV WATTS	TEST kV	L(H) / C (pF)	mA	EQUIV. 10 kV mA	EQUIV. 10 kV WATTS	IR
47																		
48																		
49																		
50																		
51																		

TURNS RATIO TEST Number of Tests: 1

52	kV		STANDARD CAP. (pF)	

	PHASE A									PHASE B									PHASE C								
	H Tap	X Tap	H Voltage	X Voltage	CALC. RATIO		kV	CAP. (pF)	TURNS RATIO	% ERROR		kV	CAP. (pF)	TURNS RATIO	% ERROR		kV	CAP. (pF)	TURNS RATIO	% ERROR
						53					54					55				

Measurements of the individual phase excitation current values are valuable in determining defects in the transformer core and coils. Excitation current measurements are generally performed on the high voltage winding only, to minimize the amount of current required.

NOTE:	*All bushing shorting leads must be removed for exciting current measurements. If the low voltage winding has a neutral, connect the neutral bushing as it normally is in-service (grounded or ungrounded).*

Measurements are usually made one phase at a time. Connections should be documented in the fields provided at the top of the table. For initial or commissioning tests, perform the measurements on each possible primary and secondary tap setting. Unless conditions warrant, future tests may be reduced to the tap settings as found.

For each test line on the form, document the DETC (De-Energized Tap Changer) and LTC (Load Tap Changer) tap settings and perform three tests per form line. On WYE / Y connected transformers, connections would be H1-H0 / U-N /A-N, H2-H0 / V-N / B-N and H3-H0 / W-N /C-N. On DELTA D (or WHYE / Y without accessible neutral) connected transformers, connections would be H1-H2 / U-V /A-B, H2-H3 / V-W / B-C and H3-H1 / W-U /C-A

To perform the individual tests, connect the HV lead to one bushing and the Red lead to the second bushing. The test mode will be automatically set on the test form to UST-R.

To initiate the individual tests, right-click on the blue highlighted field of the desired test line. The test sequence initiates and the results will be placed in the proper fields automatically.

The number of test lines in the table is adjustable. Enter the number of lines desired for the number of taps to be tested.

NOTE	*Exciting current measurements are pending voltage level. Make sure use same voltage level as in earlier measurements on same transformer. Exciting current may also vary due to core magnetization status, exciting current measurements should be performed prior winding resistance measurement or after demagnetization.*

Ratio Tests

Measurements of transformer winding ratio can be made with a high voltage power factor test set when a TTR capacitor is available. Depending on the voltage rating of the winding being energized, tests can be made up to 10kV. The significance of this is that higher volts per turn can be applied to the winding, stressing the winding turn-to-turn insulation more than low voltage ratio test sets. This may be able to detect high resistance turn faults that may be undetectable at lower voltage. The tests are performed one phase at a time on three-phase transformers.

To enable this portion of the test form, select the Show TTR Tests checkbox at the top of Page 1. A table for ratio test results will become visible near the end of the form. You should select the Number of Tests based on how many transformer taps you intend to test.

The first test must measure the capacitance of the Standard Capacitor, in pico-Farads (pF).

Connect the test set leads, the HV lead and the Red measurement lead, directly to the capacitor.

Initiate the test by right clicking on the blue field for the Standard Capacitor.

Subsequent tests require the HV lead to be connected to one side of a HV winding (e.g. H1/U/A) where the other side of the HV winding is grounded to the tank (e.g. H0/N/N). The corresponding winding on LV side is grounded on one side and on the other side is connected to Red lead via the capacitor.

By enter the winding voltage levels in the form, the assessment is automatic.

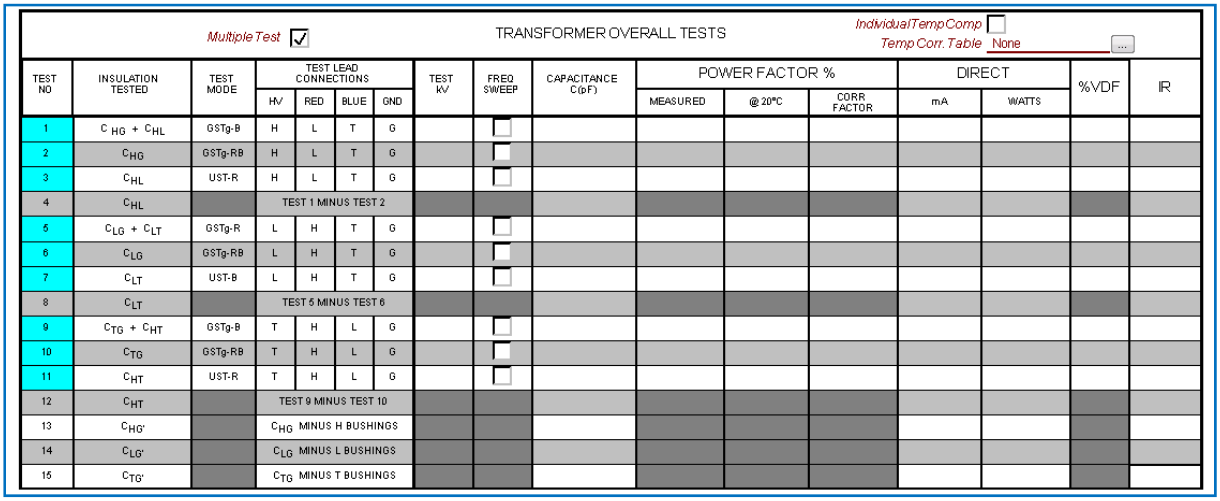
Multiple Quick Tests

Standards measurements may be complemented with additional measurements executed from the Multiple Quick Test sub-form selected as a new test or as manual measurements in the standard test forms. Check “Manual” in the select test boxes and a Multiple Quick Test table will be added at the end of the form.

In the field "INSULATION TESTED" you enter information on what to be tested, TEST MODE set/change the test mode, SUPPRESS set/change noise suppression mode.

It is also possible to use Delta Control for controlling the test by clicking the Delta Control button (above the table) in PowerDB form, Delta Control will send all data to be stored in the Multiple Quick Test table.

94500 – Three-Winding Transformer



Multiple Test ☑ TRANSFORMER OVERALL TESTS Individual Temp Comp ☐ Temp Corr. Table None

TEST NO	INSULATION TESTED	TEST MODE	TEST LEAD CONNECTIONS HV	RED	BLUE	GND	TEST kV	FREQ SWEEP	CAPACITANCE C(pF)	POWER FACTOR % MEASURED	@ 20°C	CORR FACTOR	DIRECT mA	WATTS	%VDF	IR
1	$C_{HG} + C_{HL}$	GSTg-B	H	L	T	G		☐								
2	C_{HG}	GSTg-RB	H	L	T	G		☐								
3	C_{HL}	UST-R	H	L	T	G		☐								
4	C_{HL}		TEST 1 MINUS TEST 2													
5	$C_{LG} + C_{LT}$	GSTg-R	L	H	T	G		☐								
6	C_{LG}	GSTg-RB	L	H	T	G		☐								
7	C_{LT}	UST-B	L	H	T	G		☐								
8	C_{LT}		TEST 5 MINUS TEST 6													
9	$C_{TG} + C_{HT}$	GSTg-B	T	H	L	G		☐								
10	C_{TG}	GSTg-RB	T	H	L	G		☐								
11	C_{HT}	UST-R	T	H	L	G		☐								
12	C_{HT}		TEST 9 MINUS TEST 10													
13	$C_{HG'}$		C_{HG} MINUS H BUSHINGS													
14	$C_{LG'}$		C_{LG} MINUS L BUSHINGS													
15	$C_{TG'}$		C_{TG} MINUS T BUSHINGS													

Basic Form Information

The PF Three-Winding Transformer form is used for power factor/dissipation factor testing medium and high voltage power transformers, generally those with at least one winding rated over 5kV. Nameplate information (serial number, ratings, etc.) should be entered which identifies the asset being tested, and general information regarding the test conditions (test date, weather conditions, etc.) should also be noted.

Description of Tests

Transformer Overall Tests

Prior to the overall insulation tests, short all high side (H) bushings together and short all low side (L) bushings together, keeping both windings separated. Remove ground connections from neutral bushings.

Test 1 - This is a measurement of the insulation between the transformer high voltage winding and the transformer tank, plus the insulation between the high voltage winding and the low voltage winding, both measured in parallel. Connect the HV cable to the H (high voltage) winding, connect the Red lead to the L (low voltage) winding and Blue lead to the T (tertiary) winding. Test mode is GSTg-B.

Test 2 - This is a measurement of the insulation between the transformer high voltage winding and the transformer tank. Connections are exactly the same as for Test 1. Test mode is GSTg-RB.

Test 3 - This is a measurement of the insulation between the transformer high voltage winding and the low voltage winding. Connections are exactly the same as for Test 1 and 2. Test mode is UST-R.

NOTE:	*Once Tests 1, 2 and 3 are completed, Line 4 will populate with values calculated by subtracting Test 2 from Test 1. This is applicable for values of capacitance, current and watts. Line 4 is a calculated comparison to the direct measurements of Test 3. Values on these two lines should be essentially the same. If they are not, re-check all connections and verify the proper operation of the test set. If Test 3 and Line 4 vary by more than 2%, the Insulation Rating (IR) will automatically populate with B (Bad).*

Test 5 - This is a measurement of the insulation between the transformer low voltage winding and the transformer tank, plus the insulation between the low voltage winding and the tertiary winding, both measured in parallel. Connect the HV cable to the low side (L) winding, connect the Red lead to the H winding and Blue lead to the T (tertiary) winding.. Test mode is GSTg-R.

Test 6 - This is a measurement of the insulation between the transformer low voltage winding and the transformer tank. Connections are exactly the same as for Test 5. Test mode is GSTg-RB.

Test 7 - This is a measurement of the insulation between the transformer low voltage winding and the high voltage winding. Connections are exactly the same as for Test 5 and 6. Test mode is UST-B.

NOTE:	*Once Tests 5, 6 and 7 are completed, Line 8 will populate with values calculated by subtracting Test 6 from Test 5. This is applicable for values of capacitance, current and watts. Line 8 is a calculated comparison to the direct measurements of Test 7. Values on these two lines should be essentially the same. If they are not, re-check all connections and verify the proper operation of the test set. If Test 7 and Line 8 vary by more than 2%, the Insulation Rating (IR) will automatically populate with B (Bad).*

Test 9 - This is a measurement of the insulation between the transformer tertiary winding (T) and the transformer tank, plus the insulation between the tertiary winding (T) and high voltage winding (H), both measured in parallel. Connect the HV cable to tertiary winding (T), connect the Red lead to the L winding and Blue lead to the L winding.. Test mode is GSTg-B.

Test 10 - This is a measurement of the insulation between the transformer tertiary winding and the transformer tank. Connections are exactly the same as for Test 5. Test mode is GSTg-RB.

Test 11 - This is a measurement of the insulation between the transformer tertiary winding and the high voltage winding. Connections are exactly the same as for Test 5 and 6. Test mode is UST-R.

NOTE:	*Once Tests 9, 10 and 11 are completed, Line 12 will populate with values calculated by subtracting Test 10 from Test 9. This is applicable for values of capacitance, current and watts. Line 12 is a calculated comparison to the direct measurements of Test 11. Values on these two lines should be essentially the same. If they are not, re-check all connections and verify the proper operation of the test set. If Test 11 and Line 12 vary by more than 2%, the Insulation Rating (IR) will automatically populate with B (Bad).*

Lines 13, 14 and 15 will automatically populate with calculated values once Tests 1-11 and all bushing tests are completed. Line 13 is a corrected value for the insulation of the high voltage winding to the transformer tank minus the measured losses of the high side bushings. Line 14 is a corrected value for the insulation of the low voltage winding to the transformer tank minus the measured losses of the low side bushings. Line 15 is a corrected value for the insulation of the tertiary winding to the transformer tank minus the measured losses of the tertiary bushings.

Bushing C1 Tests

If the transformer windings are terminated using condenser bushings, then measurements of the C1 insulation on each bushing are generally made. The bushing insulation C1 is internal and is the insulation between the bushing center conductor and its test tap (capacitance tap). If a bushing does not have a test tap, then the C1 measurement is not performed.

NOTE:	*These tests may be performed with the bushing shorting leads still in place from the overall insulation tests. This allows all the high side bushing C1 tests to be performed without having to move the HV lead from bushing to bushing. It will still be necessary to move the Red lead to the individual test taps for each test.*

Test 16 - This is the test of the C1 insulation on the high side phase 1 bushing. The HV lead is connected to the bushing top terminal and the Red lead is connected to the bushing test tap. Test mode is UST-R.

Tests 17, 18 and 19 are C1 measurements for the other high side bushings. Test 14 is used only if the high winding has a neutral bushing with a test tap. Make sure to move the Red lead connection from bushing to bushing as necessary. Test mode is UST-R.

Tests 20, 21, 22, and 23 are C1 measurements for the low side (L) bushings. Test 23 is used only if the high winding has a neutral bushing with a test tap. Test mode is UST-R.

Tests 24, 25, 26, and 27 are C1 measurements for the Tertiary (T) bushings. Test 27 is used only if the high winding has a neutral bushing with a test tap. Test mode is UST-R.

NOTE:	*Many condenser bushings will have factory values for C1 stamped on their nameplates, both for power factor and capacitance. The test results for C1 on each bushing can be compared directly to its respective nameplate values.*

Oil Tests

The 94500 test form includes a single test line (Test 28) for capturing the results of one power factor test on insulating oil. This is generally done on a sample of oil drawn from the main tank of the transformer under test. The test requires an oil test cell designed for field use. The test cell should be a three-terminal cell where connections for high voltage, measurement lead, and ground can be safely made.

As with the other insulation tests on this test form, the test sequence is initiated by right-clicking on the blue highlighted test number (28) at the bottom of the Bushing C1 Tests table. The test mode used is UST-R.

Bushing C2 Tests

Bushings with test taps may also be tested to obtain a C2 insulation measurement. The C2 insulation is the insulation between the test tap connection and the bushing mounting flange. To perform a C2 test, the HV lead is carefully connected to the bushing test tap and the Red lead is connected to the bushing center conductor. Care should be taken not to cause physical damage to the test tap, as the tap connection point may be a small pin or a flexible spring. If this is the case, use a small insulated jumper wire or a specially designed test tap adapter to make the HV lead connection.

CAUTION

Bushing test taps have very limited insulation and should generally be energized at reduced voltage levels. If the bushing manufacturer does not specify a test voltage level use no more than 500 volts (0.5kV).

Tests 29 to 40 are measurements of the individual bushings C2 insulation. All are performed with test mode GSTg-R. All phase and neutral bushings may be tested providing they have test taps.

NOTE:	*Similar to the bushing C1 tests, all the C2 measurements may be made with the bushing shorting leads still in place from the transformer overall tests.*

Bushing Hot Collar Tests

Hot collar tests are generally performed on HV bushings that do not have test taps. However, these tests may also be done as an additional test if the bushings have test taps

Tests 41 to 60 - These tests measure the outer shell insulation of the bushings, including surface leakage and leakage current from the bushing surface through the insulating material to the center conductor. A conductive strap is placed around the bushing, below one of the skirts, normally the top skirt, and connected to the HV lead. The Red lead is connected to the bushing conductor. Test mode GST-GND is automatically programmed by the test form.

Multiple hot collar tests can be performed on each bushing. For each test, the location of the strap should be clearly indicated on the form in the Designation column.

Surge Arresters

If the transformer is equipped with surge or lightning arresters, these may be tested as well. If the arrester is a single-stack unit, its HV connection must be disconnected to eliminate the measurement of losses from other connected apparatus (such as switch and support insulators). Multi-stack arresters may be tested without disconnecting if desired. The procedure described below assumes single-stack arresters are being tested.

Nameplate, serial number and location information for each arrester should be entered so that future testing can be compared to specific units.

Tests 61 to 72 are measurements of the arrester insulation. Only test voltage, current and watts are recorded for arresters. The HV lead is attached to the arrester HV terminal. No connection using the Red or Blue leads is necessary. The Test Mode used is GST-GND. Once the HV lead is connected, right-click on the blue highlighted field on the desired test line to initiate the test sequence. Follow the onscreen instructions to complete the test.

Turns Ratio Tests

Measurements of transformer winding ratio can be made with a high voltage power factor test set when a TTR capacitor is available. Depending on the voltage rating of the winding being energized, tests can be made up to 10kV. The significance of this is that higher volts per turn can be applied to the winding, stressing the winding turn-to-turn insulation more than low voltage ratio test sets. This may be able to detect high resistance turn faults that may be undetectable at lower voltage. The tests are performed one phase at a time on three-phase transformers.

To enable this portion of the test form, select the Show TTR Tests checkbox at the top of Page 1. A table for ratio test results will become visible near the end of the form. You should select the Number of Tests based on how many transformer taps you intend to test.

The first test must measure the capacitance of the Standard Capacitor, in pico-Farads (pF).

- Connect the test set leads, the HV lead and the Red measurement lead, directly to the capacitor.
- Initiate the test by right clicking on the blue field for the Standard Capacitor.

Subsequent tests require the HV lead to be connected to one side of a HV winding (e.g. H1/U/A) where the other side of the HV winding is grounded to the tank (e.g. H0/N/N). The corresponding winding on LV side is grounded on one side and on the other side is connected to Red lead via the capacitor.

By enter the winding voltage levels in the form, the assessment is automatic.

Exciting Current Tests

Measurements of the individual phase excitation current values are valuable in determining defects in the transformer core and coils. Excitation current measurements are generally performed on the high voltage winding only, to minimize the amount of current required.

NOTE:	*All bushing shorting leads must be removed for exciting current measurements. If the low voltage winding has a neutral, connect the neutral bushing as it normally is in-service (grounded or ungrounded).*

Measurements are usually made one phase at a time. Connections should be documented in the fields provided at the top of the table. For initial or commissioning tests, perform the measurements on each possible primary and

secondary tap setting. Unless conditions warrant, future tests may be reduced to the tap settings as found.

For each test line on the form, document the DETC (De-Energized Tap Changer) and LTC (Load Tap Changer) tap settings and perform three tests per form line. On WYE / Y connected transformers, connections would be H1-H0 / U-N /A-N, H2-H0 / V-N / B-N and H3-H0 / W-N /C-N. On DELTA D (or WHYE / Y without accessible neutral) connected transformers, connections would be H1-H2 / U-V /A-B, H2-H3 / V-W / B-C and H3-H1 / W-U /C-A

To perform the individual tests, connect the HV lead to one bushing and the Red lead to the second bushing. The test mode will be automatically set on the test form to UST-R.

To initiate the individual tests, right-click on the blue highlighted field of the desired test line. The test sequence initiates and the results will be placed in the proper fields automatically.

The number of test lines in the table is adjustable. Enter the number of lines desired for the number of taps to be tested.

NOTE:	*Exciting current measurements are pending voltage level. Make sure use same voltage level as in earlier measurements on same transformer. Exciting current may also vary due to core magnetization status, exciting current measurements should be performed prior winding resistance measurement or after demagnetization.*

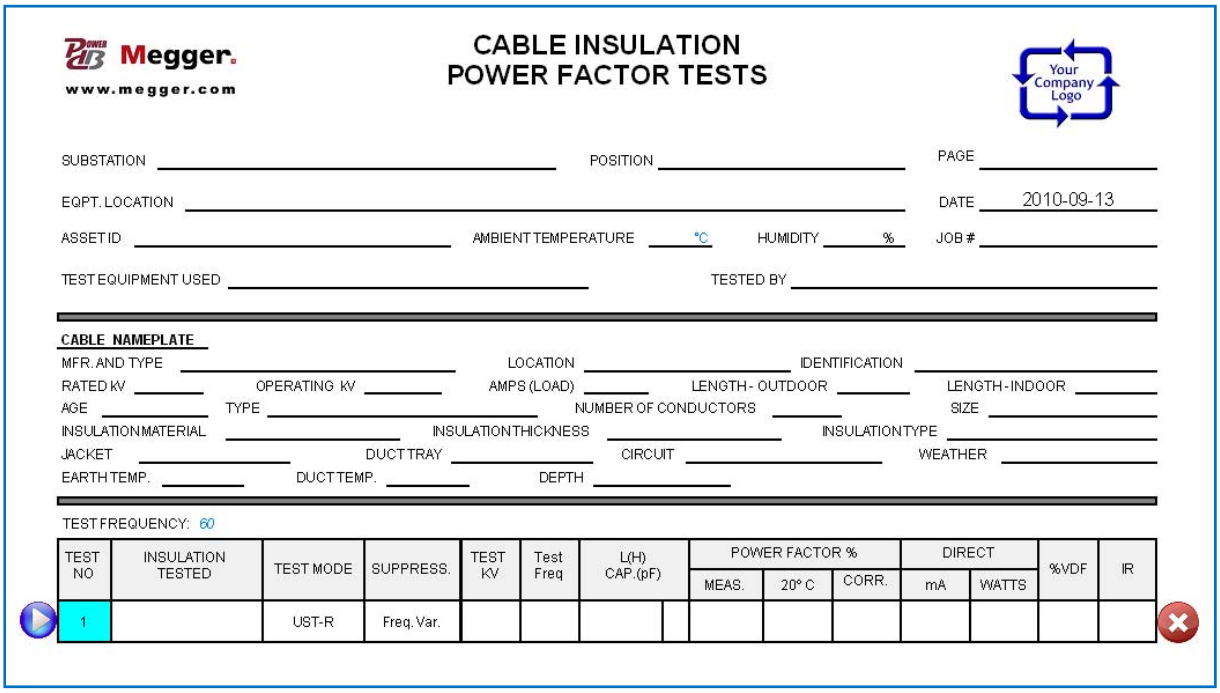
Multiple Quick Tests

Standards measurements may be complemented with additional measurements executed from the Multiple Quick Test sub-form selected as a new test or as manual measurements in the standard test forms. Check “Manual” in the select test boxes and a Multiple Quick Test table will be added at the end of the form.

In the field "INSULATION TESTED" you enter information on what to be tested, TEST MODE set/change the test mode, SUPPRESS set/change noise suppression mode.

It is also possible to use Delta Control for controlling the test by clicking the Delta Control button (above the table) in PowerDB form, Delta Control will send all data to be stored in the Multiple Quick Test table.

96005 – CABLES



Because of the many variations of cable installations, this test form is designed for flexibility in capturing test information and results.

Included is a normal "header" where location and test conditions are recorded, as well as a Cable Nameplate area for detailing specific information about the cable to be tested.

To allow for flexibility, the test table in this form is designed to grow by a line with every test added. This permits any number of cables to be tested, multiple times if necessary.

Specific information (phase designation, termination, etc.) about the cable insulation being tested should be entered in the Insulation Tested column. The appropriate test configuration must be selected from the dropdown list.

To initiate the test, right-click on the Test No in the left-most column of the table and follow the prompts provided in the pop-up window. At the conclusion of the test, the results will populate into the fields of the selected test row.

Continue testing as necessary by moving to the next row and repeating the same steps.

9

Delta 4310 User Interface

The testing procedures for the two versions of Delta4000 are principally the same. Delta4110 is operated from an external computer running Power DB Lite and Delta Control SW. Delta4310 has an internal computer with pre-installed Power DB On-board and Delta Control SW. Power DB On-board has the same functionality as Power DB Lite but the test forms are adapted to the smaller screen and the SW has support for the specific shortcut keys and buttons available on the 4310.

This section covers the specific controls on Delta4310 that differs from a standard laptop computer used together with Delta4110.

Top Panel

Test Button: 

Initiates and Terminates Testing

Navigation Keys: 
Use Arrow keys to highlight a desired Selection. Use Enter button (in center) to Activate the Selection.

Home Key: 
Toggles HOME Action Icons

Zone Key: 
Allows User to select Active area of the screen.

Keypad: Key board for entering notes and data.

Power Suspend: 
Prepares the Instrument for Shutdown. A message will indicate when Input Power can be safely removed (not used on some models)

Help Function: 

Provides on screen Help to assist operator.

Information Key: 

Provides on screen information to assist operator

Function Key: 

Displays the options available for any highlighted Selection (when applicable)

Figure 8: User Interface Panel

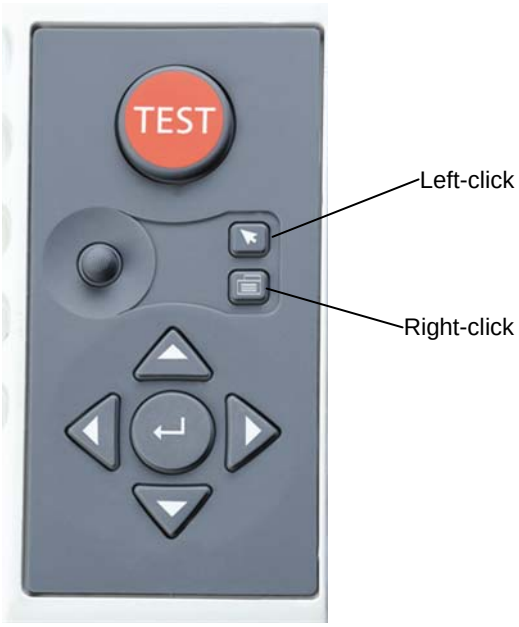
Communications Ports

Figure 9: Communications ports

4310 Joystick

The Joystick is weather-sealed with "left" and "right" buttons, similar to a 'mouse'.

The middle of the joystick contains the controls for the pointer and buttons for the 'left' (top) and 'right' (bottom) click. The TEST button has the same functionality as the 'Start' button on the instrument.



Home Action Icons

Select to create **NEW** test

Select to **RECALL** test

Select to **SAVE** Test.

Select to **ZOOM-IN**

Select to **ZOOM-OUT**

Print Icon. Prints the Selected Test Form. Printer driver is factory installed. Please contact Megger for specific printer model availability.

Select to enter **PREFERENCES** screen

Figure 10: HOME Action Icons

Utility Icons

Cancel Icon. Select to Cancel without Saving.

Delete Icon. Deletes the Selected File or Report.

Print Icon. Prints the Selected Report. Printer must be standard USB supporting HP PCL protocol.

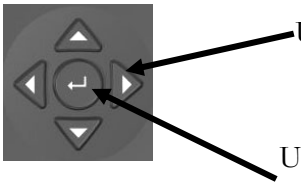
USB Out Icon. Select to Transfer Files or Reports from external USB Memory Stick to the TTR.

USB In Icon. Select to Transfer Files or Reports from the TTR to the external USB Memory Stick.

Back Icon. Select to return back to the previous screen.

Figure 11: Utility Icons

Navigating the screen



Use **Arrows** keys to **highlight** desired action

Use **ENTER** key (in center) to **select** highlighted action

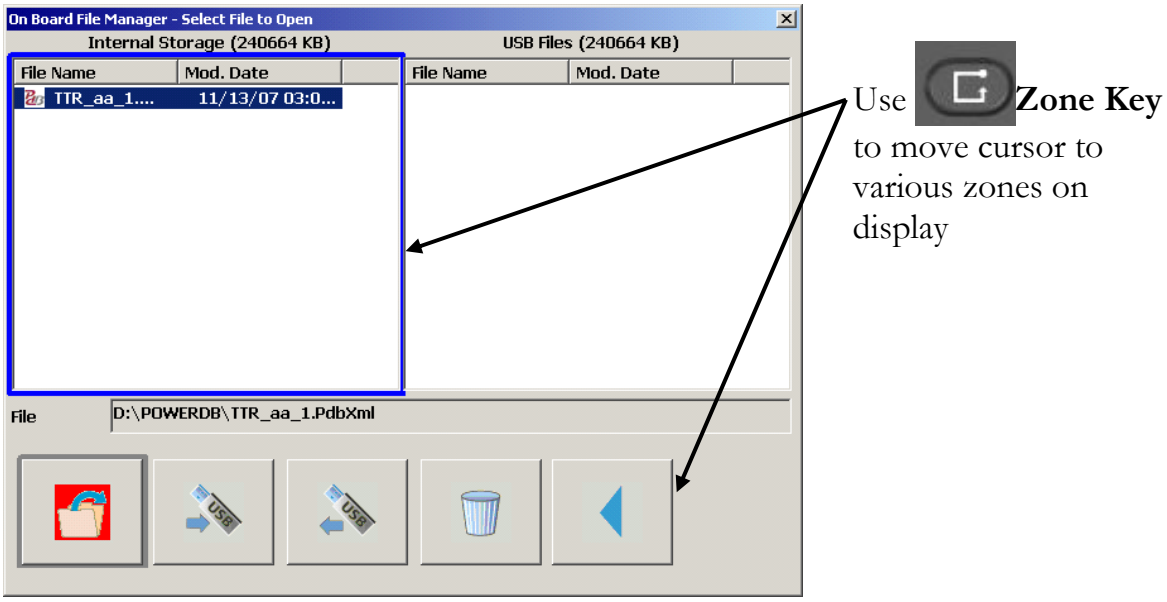
Home Screen Action Icons

Select **HOME** key to display Action Icons

Action Icons

Select **NEW TEST** to open new form

Select **RECALL** to open test from memory (either internal or USB memory)



Use **Zone Key** to move cursor to various zones on display

Figure 15: File Manager -Recall Test

Select **SAVE** to save test to memory

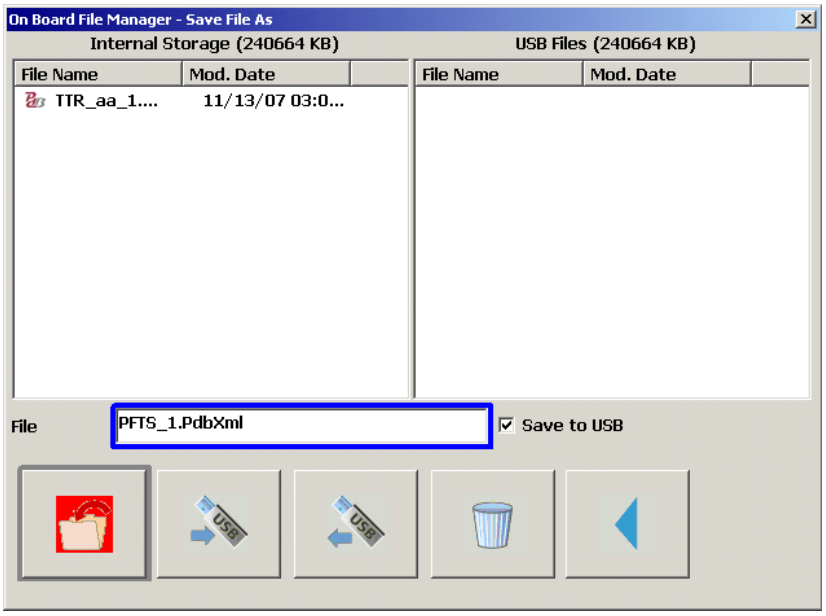
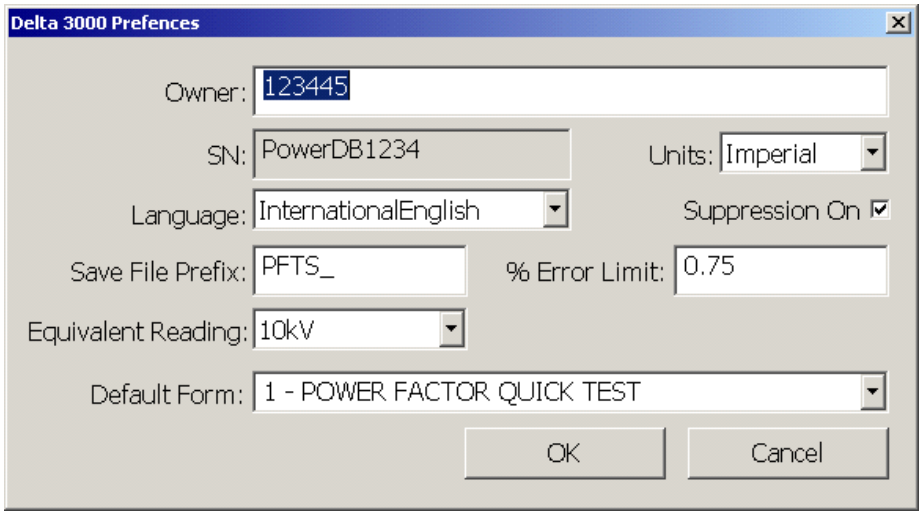


Figure 16: File Manager –SAVE Test screen

Select  PREFERENCES to set global parameters



Use  **Zone Key** to tab

Figure 17: Global Settings – Preferences screen

Owner: User specified field

SN: Serial Number of Test Instrument

Units: Units of Measure setting

Language: Indicates displayed language

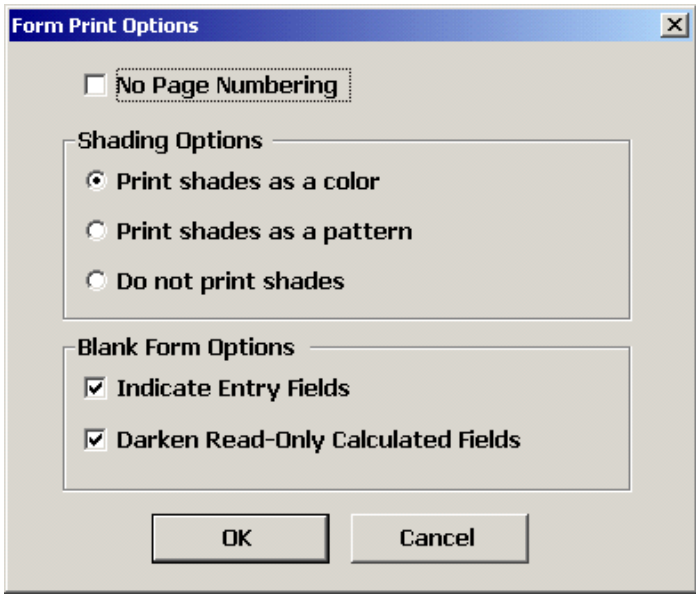
Save File Prefix: All Saved files will begin with this prefix

% Error limit: Sets error limit

Equivalent reading: Sets voltage level to display "equivalent reading" level

Default form: Indicates default form, upon power-up

Select  **PRINT** to print to USB printer



Use **SPACE** bar to select OPTIONs

Use **Zone** key to tab

Figure 18: PRINT

10

Maintenance and Calibration

Maintenance

Maintenance should be performed only by qualified persons familiar with the hazards involved with high-voltage test equipment. Read and understand Section 2, Safety, 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.

DISCONNECT the MAINS plug before cleaning.

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 sprayed on cloth 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.

Contamination of some parts of the high-voltage circuit, in particular the high-voltage cable terminations and its mating panel receptacle, may show up as a residual PF(DF) meter reading. Cleaning of these sensitive parts will remove the leakage paths which cause the unwanted leakage current. Treat the high-voltage cable with care. Keep it clean and do not subject it to abuse, such as dropping or crimping.

Calibration

During the warranty period, no calibration should be necessary. Contact the factory if there is any suspected problem.

The overall accuracy of capacitance and power factor (dissipation factor) at 10 kV should also be checked at least once a year against Megger's Capacitance and Dissipation Factor Standard (Cat. No. 670500-1). This will ensure that the entire high-voltage circuit is functioning and calibrated properly.

A calibration kit is provided as an optional accessory. This allows for traceable calibration locally without sending the unit to factory.

Factory calibration is of course also available. Contact your local Megger representative for details

Recommended calibration interval is 1-3 years.

Troubleshooting

General Guidelines

This section provides general guidelines for basic troubleshooting of the Delta4000. The Delta4000 undergoes rigorous testing before being shipped from the factory; however, when it is subjected to various field conditions, there is always the possibility of damage being done to the instrument or its cables. This troubleshooting section does not attempt to cover all possibilities, but does list suggestions that can be carried out in the field. There may be problems that require the unit to be returned to the factory for repair.

If questionable readings are obtained, the first step is to check the calibration of the Delta4000 using Megger's Capacitance and Dissipation Factor Standard (Cat. No. 670500-1). If the standard is not available, the next step is to test a specimen with a stable known value e.g. the TTR capacitor or one of the capacitors in the Megger capacitor kit. If such a specimen is not available, then perform the following procedure for an "Open Air Test."

Open Air Test

The purpose of this test is to check the overall functionality of the Delta4000, including the high-voltage cable. The readings obtained show the stray signal losses of the high-voltage cable.

1. Connect the wing nut ground terminal of the test set to a low impedance earth ground using the ground cable supplied.

2. Connect the control unit to the high-voltage unit using the two interconnection cables.

3. Connect the external interlock cables to the SAFETY INTERLOCK receptacles.

4. Connect the high-voltage cable to the HV OUTPUT terminal of the high-voltage unit (power supply). Be sure that the connector locks in place.

5. With the main breaker OFF, plug the input power cord into the test set AC POWER receptacle and into a three-wire grounded power receptacle having the appropriate voltage and current ratings.

6. Suspend the outboard end of the high-voltage cable in free air so that it is clear of all surrounding objects by at least 3 ft (0.91 m). Use dry nylon rope if available.

7. Start your Delta4000 and use Delta Control (or a PowerDB form) and perform a general GST-GND test.

When test is completed, observe test results. The results should be as follows:

Capacitance: between 4.0 and 8.0 pF

%DF or %PF: between -1.0 to +2.0%

Watts @ 10 kV: between -0.002 to +0.006

mA @ 10 kV: between 0.015 to 0.030

Repair

Megger offers a complete repair service and recommends that its customers take advantage of this service in the event of equipment malfunction. Please indicate all pertinent information including problem, symptoms, and attempted repairs. Pack the Delta4000 in its transit case and include all cables that came with the instrument. Equipment returned for repair must be shipped prepaid and insured and marked for the attention of the Repair Department.