Megger

MTO300
MTO330A

Transformer winding resistance test set

INSTRUCTION MANUAL

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.

Megger.

Valley Forge Corporate Center

2621 Van Buren Ave

Norristown, PA 19403-2329

610-676-8500 (Telephone)

610-676-8610 (Fax)

www.megger.com

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Upon receipt of product

Prior to operation, check for loosened hardware or damage incurred during transit. If these conditions are found, a safety hazard is likely, DO NOT attempt to operate equipment. Please contact Megger as soon as possible.

MTO300 Transformer Test Set

MTO330A Transformer Test Set

1

PRODUCT OVERVIEW 300/330A

The Megger Transformer Ohmmeter is a line-operated, field-portable instrument designed specifically to measure the DC resistance of all types of magnetic windings safely and accurately.

Its predominant use is the measurement of the DC resistance of all types of transformer windings within the defined range of resistance. It can also test rotating machine windings and perform low resistance measurements on connections, contacts and control circuits.

It is recommended that the user becomes familiar with the MTO before making any connection to a transformer.

The instrument provides a 10A DC output, switched to both high side and low side windings in a safe, efficient manner.

Top Panel Controls

Figure 1: MTO300 Front Panel

Figure 2: MTO330A Front Panel

Product overview 300/330A

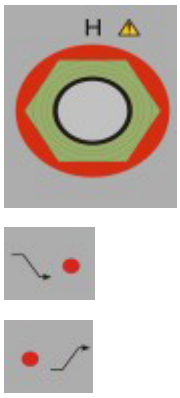
Input AC Power Module:

This module is an IEC320 interface to the mains power. The module has an integrated switch, fuse holder and input filter module. Above the module are the voltage, frequency and power requirements for the product. Below the module are the fuse type and ratings based on the input voltage used. The green light on the right side of the module illuminates when power is ON.

O , OFF position

1 (-) , ON position

Primary Interface Connection from the Transformer to the Unit:

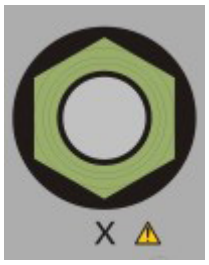


This connection has all of the interfaces required to connect current and voltage inputs from a three phase transformer into the MTO300 unit.

Discharge Indicator – blinks every ½ second when a transformer is discharging

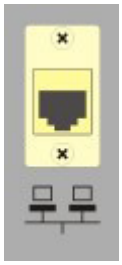
Test Indicator – stays on when a transformer is energized.

Secondary/Tertiary Interface Connection from the Transformer to the Unit:



This connection has all of the interfaces required to connect current and voltage inputs from a three phase transformer into the MTO300 unit.

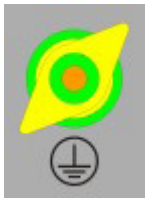
Ethernet Connection:



This connection links a PC used for control with the MTO300.

NOTE: port is not network compatible. DO NOT USE ON A LOCAL AREA NETWORK. The system was designed for peer to peer operation.

Earth/Ground Lug:



This connection is used to connect a transformer under test to earth ground for safety. The transformer and the MTO shall be at the power ground/earth potential when being operated.

Emergency Shut Down Switch:

This switch, when pushed will disable the source power supply and automatically discharge the transformer. The instrument is continuously monitoring this switch in the event of an emergency. If the switch is engaged, no testing can commence.

Remote Control Switch (MTO300 ONLY)

This connector is used to interface with a remote switch. This switch is primarily used when testing On-Load Taps of a transformer

The Remote Control Switch can remotely start the MTO test and store multiple resistances reading for tap changes. The storage function in remote mode is sequential and occurs during a continuous resistance test.

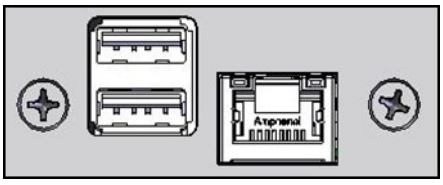
Product overview 300/330A

MTO330A Top Panel Facilities

Figure 3: MTO330A Optional Controller with Display

The optional industrial 12 inch controller is:

1. **Industrial 305 mm (12 inch) Touch Display:** Used in place of a PC. Designed to run PowerDB Lite with focus on selected Megger instrument control related to transformer testing. When turned on, defaults to MTO transformer forms.
2. **Built-in Printer:** Designed to print individual results and is active within specific forms via 'print icon' located within selected forms.
3. **USB Port:** Used for various functions including external memory and external mouse/keyboard control.



4. **Rear USB Port Hub:** Used for external Megger instrument control such as Delta4000, S1/MIT Insulation test set, MLR10.
5. **Rear Ethernet Port:** Used for external Megger instrument control – specifically the Delta4000, TTR3XX, MLR10, S1/MIT series.

The MTO330A 305 mm (12 inch) display is meant to replace a customer PC with an industrial controller designed to work in harsh environments. This built- in display features protection against accidental shut down of the instrument by safely turning off Windows operating system together with PowerDB after shutdown (switch is turned off) is detected. This safe shutdown prevents damage to the internal memory, and to the software operating system.

2

SAFETY

Safety is the Responsibility of the User

Only qualified and trained operators should operate the MTO300/330A. Operator must read and understand this entire Instruction Manual prior to operating the equipment. Operator must follow the instructions of this Instruction Manual and attend the equipment while the equipment is in use. In the event of equipment malfunction, the unit should immediately be de-energized and returned to Megger for repair. The Safety precautions, herein, are not intended to replace your Company's Safety Procedures. Refer to IEEE 510 - 1983, IEEE Recommended Practices for Safety in High-Voltage and High-Power Testing, for additional information.

General Safety Precautions

The MTO300/330A and the Unit Under Test (UUT) should both be considered as sources of instantaneously lethal levels of electrical energy. Observe the following safety precautions:

- Observe all safety warnings on the equipment. They identify areas of immediate hazard that could result in injury or death.
- Use this equipment only for the purposes described in this manual. Observe strictly the Warning and Caution information provided in this manual
- Treat all terminals of high-voltage power equipment systems as potential electric shock hazards. Use all practical safety precautions to prevent contact with energized parts of the equipment and related circuits.
- Use suitable barriers, barricades, or warnings to keep persons not directly involved with the work away from test activities.
- Never connect the test equipment to energized equipment.
- Do not use in an explosive atmosphere.
- Use the grounding and connection procedures recommended in this manual. Always disconnect test leads from power equipment before attempting to disconnect them at the test set. The ground connection must be the first made and the last removed. Any interruption of the grounding connection can create an electrical shock hazard.
- Personnel using heart pacemakers should obtain expert advice on the possible risks before operating this equipment or being close to the equipment during operation.

Input Power Precautions

This instrument operates from a single-phase, sine wave, power source. It has a three-wire power cord and requires a two-pole, three-terminal (live, neutral, and ground) type input source. The voltage to ground from the live pole of the power source must be within the following rated operating voltage:

Cat. No MTO300 108-132V/ 207-253V*, 50/60 Hz, ±2 Hz, 660VA

Cat. No. MTO330A 108-132V/ 207-253V* 50/60 Hz, ±2 Hz, 660VA

*- Requires a fuse change for safe operation – see Specifications below

The neutral pole must be at ground potential. Before making connection to the power source, determine that the instrument rating matches the voltage of the power source. 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.

For test sets energized with 230V input, the neutral terminal of the input supply cord (white or blue lead) must be connected to the neutral pole of the line power source. The ground terminal of the input supply cord (green or yellow/green lead) must be connected to the protective ground (earth) terminal of the line power source. The black or brown cord lead is the live (hot) lead.

The control circuits of the instrument are protected by two mains circuit fuses. These fuses are located in the ON/OFF switch module and are replaceable by the operator. To avoid electric shock and fire hazard, use only the fuse specified in Section 3 - Specifications that is identical in respect to type, voltage rating, and current rating.

WARNING

Before replacing the fuses, disconnect the power input plug from the live power source.

PC Interface Precautions

The MTO300 instrument was designed to operate as a peer to peer connection between a Personal Computer with Windows OS and the Test Unit.

- Unit is NOT designed for network operation. DO NOT Connect MTO300 to a network.
- The TCPIP interface selected for MTO is in the limited connectivity AutoIP address range. PC's will take approximately 1 minute to auto-address the MTO unit.
- The internal server IP address is 169.254.1.2, Subnet Mask 255.255.0.0.

The MTO330A is an industrial PC. For network operability it may need to be registered with your IT department, but this is only required for any specialized actions authorized by the Megger Valley Forge factory.

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SPECIFICATIONS

Electrical

Input Power

Cat. No. MTO300/330A: 108-132V, 60 Hz, ±2 Hz, 660 VA

(207-253V with fuse change to 4.0 amp*)

IEC 1010-1 installation category II

Protective Devices (Fuses)

Main Input Fuse : Qty 2: 6.3 amp, 250V, 5x20mm, SLO-BLO

Qty 2: 4.0 amp, 250V, 5x20mm, SLO-BLO

Winding Resistance Specifications

DC Output Current (User Selectable Ranges)

10 mA

100 mA

1 A

2.5 A

5.0 A

7.5 A

10 A

Open Circuit Test Voltage

40V dc

Measurement Voltage

20V dc

Max Power

200VA continuous

Specifications

Resistance Ranges

Current Range (A)	Resistance Range (Ω)	Resolution ((Ω)
10 A	10 µΩ to 0.2 Ω	0.000001
10 A	0.2 Ω to 2 Ω	0.0001
1 A	100 µΩ to 2 Ω	0.00001
1 A	2 Ω to 20 Ω	0.001
100 mA	1 mΩ to 20 Ω	0.0001
100 mA	20 Ω to 200 Ω	0.01
10 mA	10 mΩ to 200 Ω	0.001
10 mA	200 Ω to 2000 Ω	0.1

Guaranteed Accuracy: +/-0.25% Range +/-0.25% rdg

Display

MTO300: Via external PC (user supplied)

MTO330A: Size: 12 inch (305mm), Brightness: 1600 NIT, Operating Temp Range: -10C to +50C operation, Type: 4 wire resistive (touch)

Memory Storage

MTO300: Via external PC (user supplied)

MTO330A: 32GB internal

Communication Interface

MTO300: USB 2.0 Serial

MTO330A: Internal for MTO operation or external port USB 2.0 Serial, or Ethernet 10/100 for Delta4000/ S1/MIT/ MLR10 operation. (The 12 inch display is able to control above instruments via PowerDB software installed within the instrument.

Safety/EMC/Vibration

Conforms to the requirements of:

IEC1010-1: 2010 CE

ASTMD999.75

IEC 61326-1:2012*

*At radiated frequencies 80MHz – 100MHz, performance may be deteriorated.

Environmental Conditions

Operating Temperature Range: 14° to 122°F (-10 to 50 °C)

Storage Temperature Range: -22° to 158°F (-30 to 70 °C)

Relative Humidity: 0 to 90% noncondensing

Physical Data

Dimensions:

Instrument: 8 H x 21.5 W x 13 D in.

(216H x 546 W x 330D mm)

Weight:

MTO300 with standard provided accessories:	29 lbs. (13.1kg)
MTO330A with standard provided accessories:	33 lbs (14.9 kg)
with Optional Leads, 30 ft (9m)	Add 18 lbs (+8 kg)

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SOFTWARE INSTALLATION

PowerDB Lite Setup & Installation (PC Control only)

PowerDB Lite software is included at no extra charge software tool that is designed specifically to control and/or extract data from the MTO300/330A. PowerDB Lite will present your test data into a professional looking data form that can be sent to a printer or .pdf file.

PowerDB Lite allows you to use a subset of the standard PowerDB forms that are appropriate for specific Megger instruments.

Minimum Recommended System

Operating System: Windows 7 or later

RAM: 2GB RAM minimum, >4GB RAM recommended

>2G free memory space

Processor: 2.0G Hz Pentium Class processor minimum,

For more information please visit www.powerdb.com or contact your local sales representative.

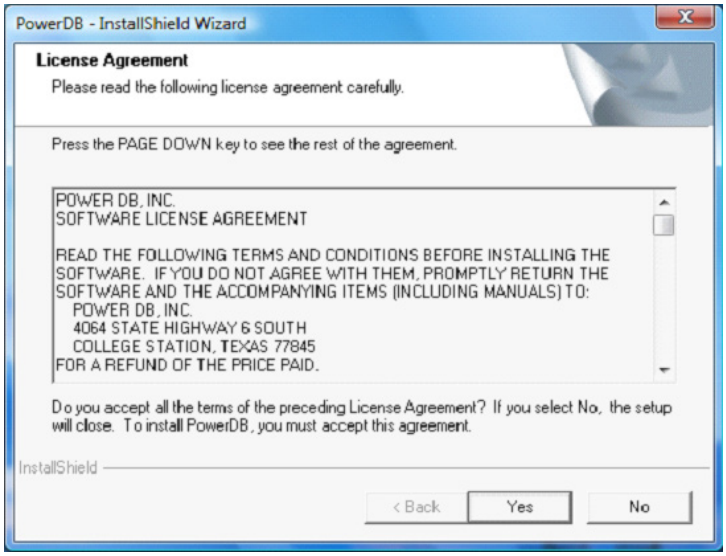
The MTO330A has PowerDB Lite preloaded on the built-in industrial controller, and will turn on at the 'MTO Test Forms' selection screen. MTO330A is designed to make testing more intuitive for end users, and so restricts the use of the built-in controller to PowerDB functions. The presentation and testing methods within the built-in controller are identical to the PowerDB Lite PC version. No difference in operation exists, except where upgrades between the PC and the MTO330A are not maintained. Upgrading the MTO330A is different than upgrading a PC. Please refer to Megger website similar to: http://us.megger.com/my-account/software-downloads/for latest 'On Board' download software and instructions.

Software Installation (PC portion only)

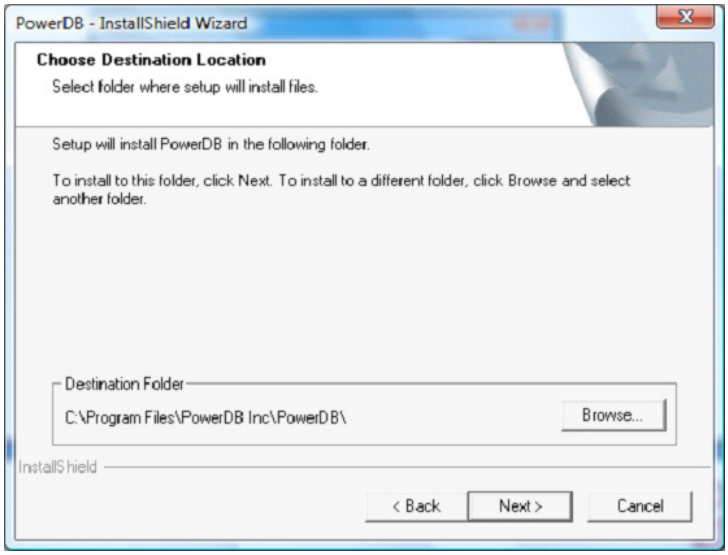
To install PowerDB Lite, load the PowerDB Lite USB into your PC computer drive and follow the on-screen instructions. For latest version, please go to website www.powerDB.com/download /PowerDBLite and download latest PowerDB Lite version available.

NOTE: For MTO330A, software version is available, on request, from Megger Valley Forge Support Team. It will load onto the MTO330A via the USB memory port on the controller portion. The model is contained within the software and not obvious until PowerDB Lite software is loaded.

1. Accept the terms of the License Agreement.

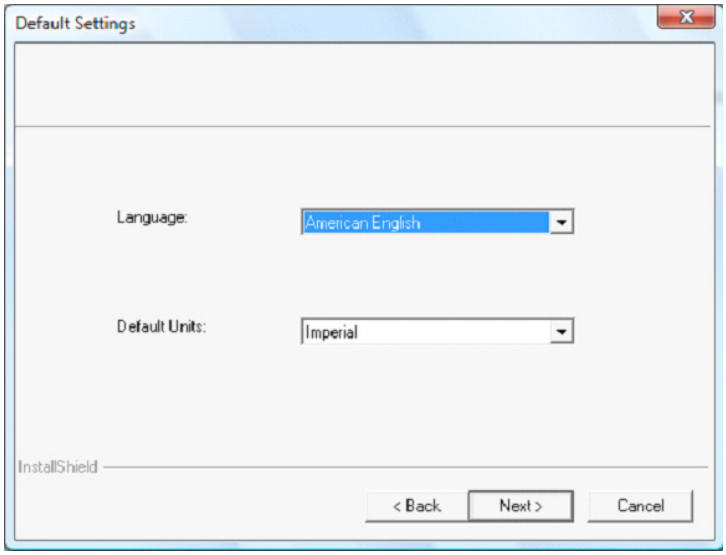


2. Choose the destination location for the PowerDB Lite files.



Software installation

3. Select Default Settings (Language and Units of Measure).



4. Install Shield Wizard will complete the installation of PowerDB Lite. Click ***Finish*** to close the installation program.

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GENERAL TESTING PROCEDURES

Site Preparation

Choose a location that meets the following conditions:

- The location is as dry as possible.
- There is no flammable material stored in the vicinity.
- The test area is adequately ventilated.
- Be sure all equipment is de-energized and all terminals of the Unit Under Test (UUT) are accessible.
- Erect suitable safety barriers to protect the operator from traffic hazards and to prevent intrusion by unauthorized personnel. User provided Warning lights are recommended.
- Verify that the Local station ground is intact and has impedance continuity to earth.

Making Circuit Connections

Connections should be made in the order as listed below.

1. **Ground.** Use the Megger supplied Safety Ground Cable (15 ft (4.6 m)) to connect the MTO Wing Nut Ground Terminal directly to Local Station Earth Ground. Ensure that the Transformer chassis also has a low impedance connection to Local Station Earth ground potential.
2. **Input Power Source Ground.** Input Power Source Ground Terminal should be less than 100 milliohms of impedance to Local Station Earth Ground.
3. **Connect the Input Power Cord.** Before making this connection, insure the Input Power Source meets the requirements as listed in Section 2 Safety and the specifications as listed in the datasheet. Also make sure that the ON/OFF switch (see Figure 1) is in the OFF position. Connect the input power cable to the MTO first, then to the power source. At this time, leave the ON/OFF switch in the OFF position.
4. **Connect the Ethernet Cable.** If using a remote PC and PowerDB Lite software, connect the Ethernet cable from the MTO330A back panel or the MTO300 front panel to the PC Ethernet port. A standard RJ45 Ethernet cable will work fine for this application. Connect the PC Ethernet output to the MTO300/330A at this time.
5. **Connect the Remote Control Cable (MTO300 ONLY).** If the user chooses to operate the MTO from a remote distance then, connect the RCC cable at this time.
6. **Connect the H and X Leads (to the MTO end only at this time).** With the clamps disconnected from the UUT, connect the H and X cables to the MTO at this time. Be sure that all plugs are fastened securely to the MTO so they will not become loose even in the event of the operator inadvertently tripping over the current leads. Once the connectors are inserted into the panel, a ¼ turn locking mechanism will secure the connection.
7. **Connecting to the Transformer.** When testing high-voltage transformers, caution must be used at all times and all safety precautions followed. Read, understand, and employ all safety precautions and circuit connections described above and in Sections 2 Safety.

General testing procedures

WARNING

Ensure that the transformer to be tested is completely de-energized. Check every winding. Ensure that all terminals of the transformer are disconnected from line or load at the transformer. Connections to ground may be left in place.

WARNING

For all testing as described herein, care shall be taken to ensure any and all unused clamps be isolated from each other, from ground, and from personnel.

At this time, make the connections to the Transformer Under Test (TUT), as described in the applicable section of

Operating the MTO300/330A

When testing high-voltage transformers, caution must be used at all times and all safety precautions followed. Read, understand, and employ all safety precautions and circuit connections described above and in Section 2 Safety.

WARNING

Ensure that the transformer to be tested is completely de-energized. Check every winding. Ensure that all terminals of the transformer are disconnected from line or load at the transformer. Connections to ground may be left in place.

WARNING

For all testing as described herein, care shall be taken to ensure any and all unused clamps shall be isolated from each other, from ground, and from personnel.

EMERGENCY SHUTDOWN PROCEDURE

Press red EMERGENCY TEST OFF push button  or switch power off.

Description of Test Sequence

Once all the precautions and steps listed above and in Section 2 Safety are complete, and the connections to the Transformer Under Test (TUT) have been made, then the input switch may be switched to the ON position.

0 , OFF position

1 (-) , ON position

AUTOMATIC DISCHARGE Function

Discharge of a transformer after testing is critical to prevent excessive voltage buildup across the transformer bushings upon removal of leads. When any current source is disconnected from a transformer, the energy in a transformer will continue to flow. If there is high impedance (air) in the nature current loop, the voltage across the inductor will increase until there is a current path found for the energy. The MTO3XX has discharge circuitry built-in. It will automatically initiate when the current source is disconnected from the transformer. It will also provide visual indication of discharging on the front panel and the PC screen.

DEMAGNETIZATION Function

The demagnetization of a transformer after DC winding resistance testing is recommended. This will ensure smooth startup and consistent diagnostic results. If not performed, there may be a residual flux present in the transformer at startup. Inrush currents on the primary side of the transformer may exceed relay settings for shutdown. Demagnetization is also recommended before performing SFRA and excitation current measurements.

MTO demagnetizes the transformer by automatically magnetizing the core of the transformer in the positive and negative direction with multiple cycles of reduced current. During demagnetization, the system will display what cycle the unit is processing.

Primary H leads need to be the only leads attached for effective demagnetization.

NOTE: The demagnetization cycle will take some time for completion. It is equivalent to taking multiple tests in sequence.

REMOTE TEST Function (MTO300 ONLY)

The main purpose of this function is to take sequential data to storage during a single test. It is useful for tap change testing where multiple resistance values are read in sequence with no interruption in current flow.

1. Connect Remote Control Cable to the remote connector on the front panel of the instrument.

2. Power ON (-) the instrument.
3. Start PowerDB software and follow the standard transformer setup procedures
4. Once the MTO3XX control software is displayed, the remote button will be automatically detected and the test button on the screen will display ACTIVE.
5. STATE 1 – ready condition – Indicator will be off.

   The operator will go to the tap changer, verify it is in the correct starting position, and then to start the first test, press  .
6. STATE 2 – Transformer Charging and/or Stabilizing – The Remote Indicator will slow flash (once per second) (ON,OFF,ON,OFF) to indicate charging.
7. STATE 3 – Stable Reading/ measurement mode - When the Remote Indicator goes steady (L,L,L,L) the reading is stable. (Y Stability and X timeframe)

General testing procedures

8. Pressing  will cause the stable result to be saved to memory. The Remote Indicator will flash quickly 6 times. (L,O,L,O) ¼ second cycle.
9. STATE 4 – Transition monitoring phase - After a save, the MTO screen will present a message requesting the user to change the TAP. At this point, the transition monitoring circuit is activated. The Remote Indicator will flash quickly 3 time and pause three times

   (L,O,L,O,L,O/O,O,O,O,O,O/L,O,L,O,L,O) ¼ sec cycle.
10. User should change the TAP.
11. If the current transition detection occurs, the unit goes into STATE 5 - (5ms, 20ms, 40ms, 80ms) and the Remote Indicator will flash rapidly. (L,O,L,O) ¼ sec interval continuously. The user can go back to the User interface for repeat of test or can press the remote button, save the event and start reading the resistance of the next tap.
12. If a 200 milli-seconds current transition detection has occurred, Discharge State will be initiated. Remote Indicator will flash slowly until a discharge has occurred. The Remote Indicator will slow flash (once per second) (ON,OFF,ON,OFF) to indicate discharging.
13. Press  to record the reading again and the process continues until all transformer taps are tested.

6

THREE-PHASE TRANSFORMER & WINDING RESISTANCE TESTING

WARNING

When testing a transformer or regulator, make sure that a good ground is placed on the test specimen as shown on all connection diagrams.

General

Winding resistance measurements in transformers are of fundamental importance for the following purposes:

- Calculations of the I2R component of conductor losses (factory test).
- Calculation of winding temperature at the end of a temperature test cycle, (factory test).
- As a diagnostic tool for field testing a transformer for assessing possible damage in the field e.g. additional contact resistance in the current paths from winding to bushing or in the tap changer.

Transformers are subject to vibration. Problems or faults occur due to poor design, assembly, handing, poor environments, overloading or poor maintenance. Measuring the resistance of the windings and termination resistance assures that the connections are correct and the resistance measurements indicate that there are no severe mismatches or opens. Many transformers have taps built into them. These taps allow ratio to be increased or decreased by fractions of a percent. Any of the ratio changes involve a mechanical movement of a contact from one position to another. These tap changes should also be checked during a winding resistance test.

PROCEDURE:

1. Connect line cord to unit and plug into 120 V/230 V socket.
2. Connect Safety GND cord from Top Panel to Transformer GND.
3. MTO300- Connect Ethernet cable between PC and MTO300.
4. Connect H and/or X lead set to the MTO3XX.
5. Connect the H and/or X lead set to the Transformer.
6. Turn the MTO300/330A power switch “ON” (-).
7. For PC operation, turn the PC power “ON”.
8. MTO300/330A Start the PowerDB program. For detailed information on PowerDB, please refer to the PowerDB user manual and additionally the Help Screen for the software. The Help screen and PowerDB manuals will stay more up to date than this manual.
9. MTO300/330A and PowerDB Lite - Select the instrument MTO300/330A from the instrument setup screen. See Figures 4a & 4b, below.

Three-phase transformer & winding resistance testing

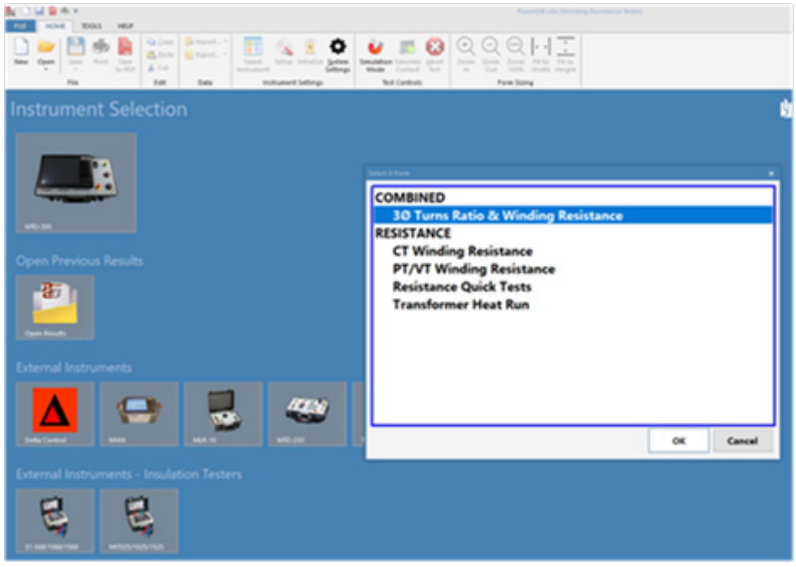


Figure 4a: MTO Display on Startup

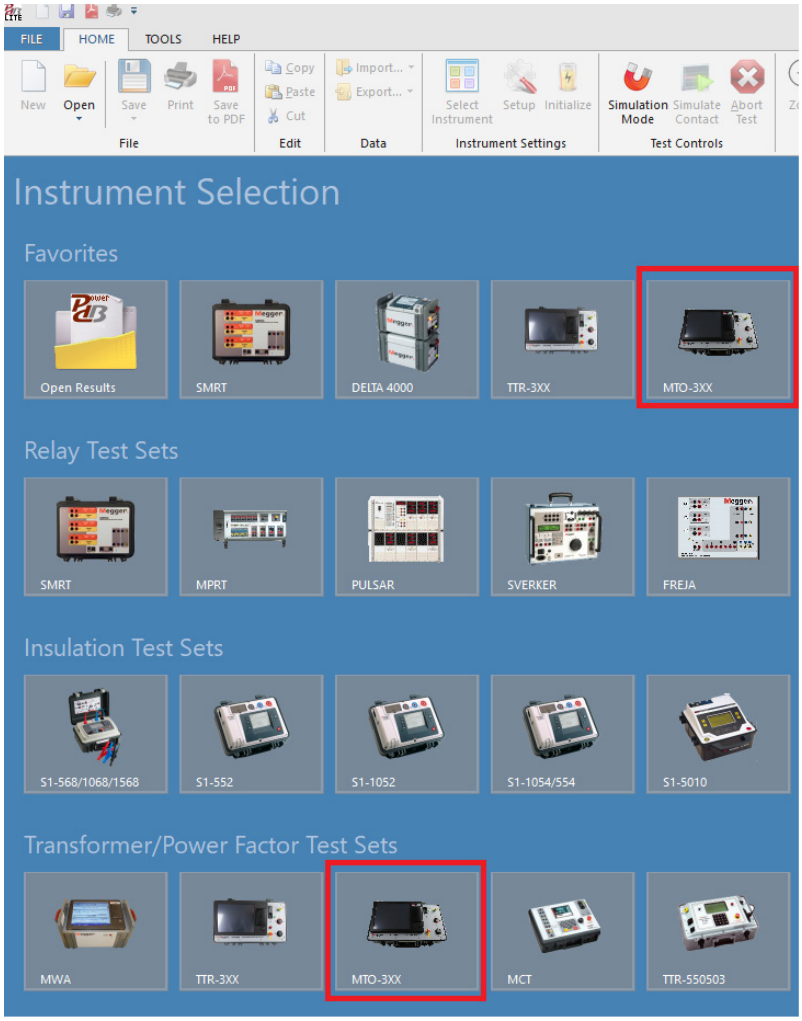
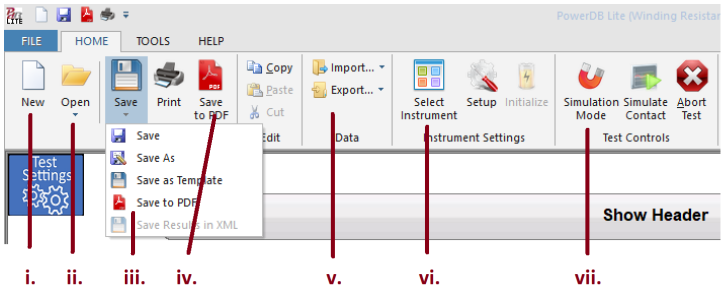


Figure 4b: MTO300/330A using PC Software

10. MTO300/330A - Select the form desired for use. This manual employs form 3Ø Turns Ratio & Winding Resistance.
11. The form will be displayed and the user will be ready to start the process.

Test Form Controls - General

Once a form is opened, all forms have a set of standard controls which are available across the top of the form as shown below. This allows common functions such as saving, deleting, opening results, together with functions as described below.



i. **New:** Allows a different test form to be selected within the MTO - brings up selection list from menu in Item i above.

ii. **Open:** Results or test setups to be used for viewing past results, appending or retesting.

iii. **Save:** Prompts user to save results, or rename file, or save in PDF format.

iv. **Save to PDF:** Allows test report to be saved in a format which is shared or stored without need to have PowerDB to view results

v. **Import/Export:** Allows saving results as a CSV (Excel) file.

vi. **Select Instrument:** Allows change of test instrument under PowerDB control as noted in 'Item 1 - Getting Started' above.

vii. **Simulation Mode:** Allows use of a test form without the actual instrument connected. Useful for training and demonstration to personnel.

1. IF desired, ENABLE and enter the Header information (see Figure 5 below) with pertinent information.

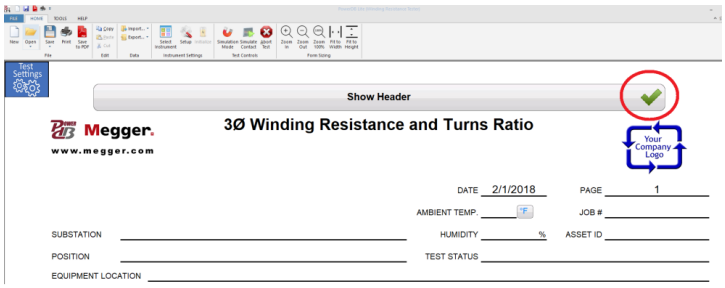


Figure 5: Header Input

2. Enter the transformer nameplate information. The required fields are highlighted below.

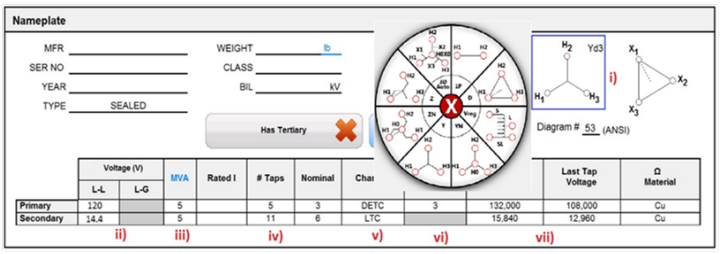


Figure 6: Nameplate Input

viii. Vector Selection: Once form setting (above) selects proper standard, one depresses the vector and a 'pop up' Vector Selector will appear, or 'right click' to select primary and secondary vector until it matches Transformer Nameplate.

ix. Transformer Nameplate Voltages: Line-to-line only, in volts.

x. Nameplate Power Rating: Typically with no cooling operation. Depress 'MVA' to toggle to 'KVA'. Once filled in, 'Rated I' will calculate and display using parameters provided.

xi. # Taps: Input from nameplate. As well, confirm NOMINAL tap positions are correct.

xii. Tap Changer: Toggle to 'DETC/OLTC' type for Primary/Secondary/Tertiary (if applicable). PROPER INPUT IS REQUIRED FOR AUTOMATED WINDING RESISTANCE TESTING.

xiii. Tap Setting: Tap # of position DETC is found. This is also used to confirm that DETC is left in proper position when testing is complete.

xiv. First/Last Tap Voltage: Required for calculation of expected voltages (and ratio) for each tap position as well as % Ratio Error Calculations.

Transformer Test Conditions

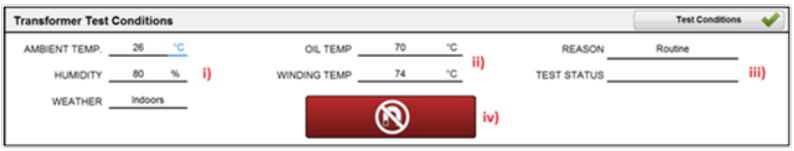


Figure 7: Transformer Test Conditions

i. **Environmental (Weather) Test Conditions:** Input.

ii. **Oil/Winding Temperature:** Readings input from transformer temperature gauges and used for optional correction of results to normalized temperatures.

iii. **Test Status:** Once testing is complete, indicates condition of the asset under test.

iv. **Demagnetization:** Once depressed, begins demagnetizing transformer winding, and confirms 'demagnetization' once complete.

Instrument Settings Button

Setup the MTO for the desired testing conditions.

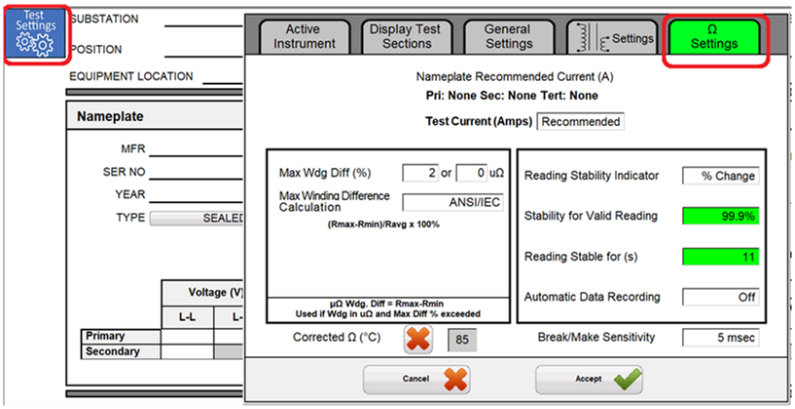


Figure 8: Instrument Setup Screen – Test Settings/Ω Settings

a. Select "Ω Settings".

b. Select Test Current. If "Recommended" is selected, operator MUST input transformer nameplate information for "L-L Voltage + kVA/MVA" of transformer (see Figure 6 above).

c. Select Max Wdg Diff level (defaulted to 2%) + low resistance offset if required (see Item 16 below for complete description)

d. Determine Corrected Resistance Temperature or "X" to disable

e. Determine Reading Stability Indictator – "% Change" recommended for most transformers, but when test large or highly inductive transformers, selecting "Last digit change" enables a slow changing resistance reading to be detected more clearly (use lower # digits for more sensitivity to change).

f. Reading Stable(s) is used in combination with Stability Indicator to determine desired stability condition (longer time = higher stability certainty).

g. Automatic Data Reading enables results to be recorded once conditions of Reading Stability Indicator(%) + Reading Stable Time(s) are reached. This mode helps improve test time efficiency BUT one must be careful and be sure that results are only recorded once readings are truly stable.

h. Make/Break Sensitivity – Only used when OLTC is selected in the Transformer Namplate input (Figure 6 above). The general rule is to set lower time (5msec) for better type OLTC units. For some older OLTC units, and for small pole top regulators, the sensitivity is set higher than 5msec (up to 100msec). Above 200msec will create a current discharge action within the MTO current source.

3. Ω Max Wdg Diff: This limit helps identify problem tap windings by setting limits. Standards such as IEEE C57.2013 define allowable limits at 2%, but limit can be changed as desired.

Calculation for % difference for each tap winding resistance:

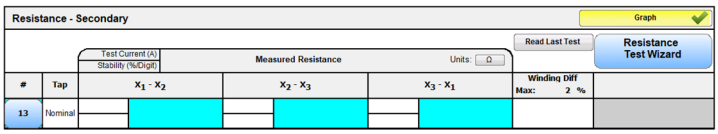
(Phase 1Ω + Phase 2Ω + Phase 3Ω)/3 = Ravg Ω

% Difference (displayed) = (Ωmax - Ωmin)/Ravg * 100

NOTE: An additional allowance has been added for transformer windings with very low resistance (< 1000 uΩ). When testing these low resistance windings, a small change of resistance makes a large change in % Winding Difference, which may be due to various factors including position of test clamps and accuracy tolerance at low resistance limits. Use of this feature is meant to help "pass" results which show good results which would otherwise show a "fail" condition for no valid reason.

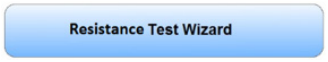
Winding Resistance Testing Methods

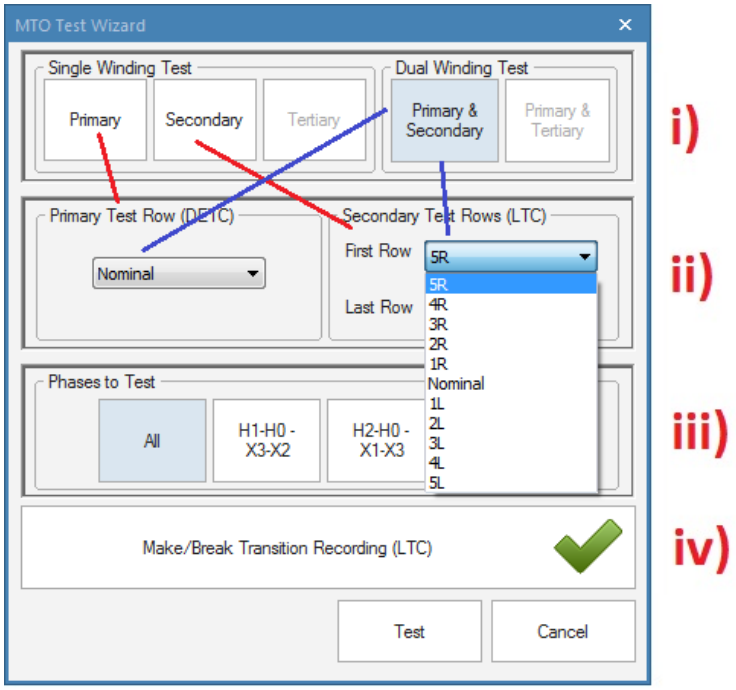
Descriptions for the following testing methods described below involve 3 methods of performing testing.



1. An automated sequence is determined and test operates through each winding and tap as required – Resistance Test Wizard . Method 1 allows an automated sequence of winding resistance testing defined by *Transformer Nameplate Input* (Figure 6 above) *and Resistance Test Wizard.*
2. All phases of a winding tap are measured in sequence – 18 .
3. Basic test method where ONLY one reading is measured and taken at a time - 10.20 .

4. **Read Last Resistance Test:** Allows population of form from an interrupted test sequence. Software keeps past results within internal log files in the event of an interruption.

Method 1 - Resistance Test Wizard - 



i)

ii)

iii)

iv)

Resistance Test Wizard is designed to automate the winding resistance test, allowing the Transformer Nameplate Input above is combined with operator selection of taps to complete a test sequence with minimal button presses. This wizard also allows testing of OLTC taps without discharge of test current during transition (between) of taps, making testing both more efficient (less time charging and discharging winding and less button pressing) as well as diagnostic by indication of a make break condition.

NOTE: When selecting *'All'* phases, multiple phases are tested concurrently. This approach improves test time, BUT has a potential drawback when testing WyeN and 3-phase Auto windings. The resistance of the neutral bushing is excluded in the first measurements because test current does not flow through the neutral bushing. This results in lower than expected readings on the outer 2 phases, which can exceed the "% Difference" limit for testing. To correct this situation, select individual tests for each phase.

i. **Winding Selection:** Allows choice of winding(s) to be tested.

ii. **Tap Selection:** Enables selection of tap(s) to be tested, as well as test direction via tap changer (OLTC) direction in which test will be conducted.

iii. **Phases to Test:** Allows choice of which single, or 3-phase windings are to be tested.

iv. **Make-Break Transition Recording:** For OLTC tap changers can be enabled/disabled within this control. Pass/Fail criteria are controlled in Resistance Test Wizard Setup above.

Method 2 – Measuring Tap – All Phases Winding Resistance - 

i. **Test #:** Depressing this button commences testing for a specific tap row (circled). Testing is conducted sequentially (up to 2 windings at once), ensuring optimization of magnetized core.

ii. **Test Current:** Records the dc current amplitude recorded for the result.

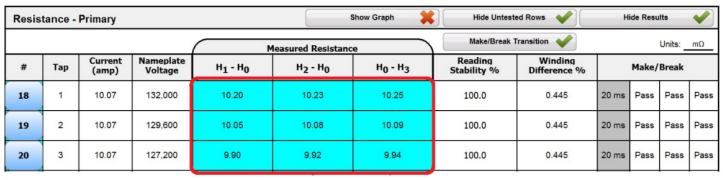
iii. **Measured Resistance:** Displays results once test is complete.

iv. **Reading Stability %:** To ensure reliable resistance readings, instrument includes a Reading Stability indicator. For large inductive transformers, readings are often obtained prematurely and this ensures proper time for valid readings. See Resistance Test Wizard Setup for more detail.

v. **Winding Difference %:** Displays a calculation between 3 phases of each tap versus a calculated average. Useful in providing a quick pass/fail condition for each tap position. Limit defaults to 2% (from IEC/IEEE standards) but can be changed in Form Settings, above.

vi. **Make/Break:** Validates proper basic operation of an OLTC during transition between taps. Optimal (good quality) tap changers will pass with a sensitive setting of 5msec. Each OLTC will be different, so various levels are available, including 'Disabled'. Control is set from Resistance Settings Diagram 8 above.

Method 3 – Measuring Individual Tap Winding

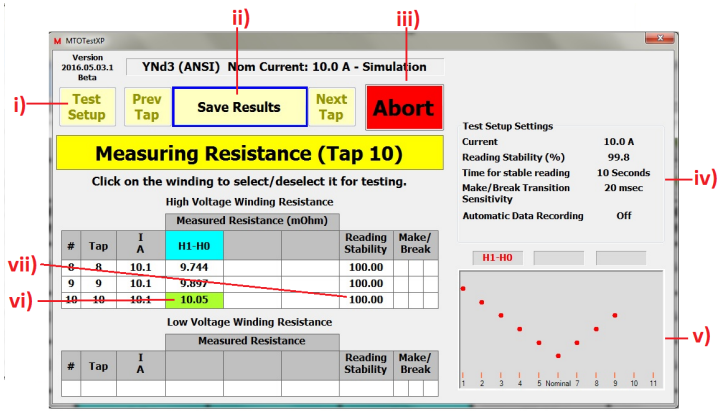


To begin testing an individual winding, simply depress using (right click) the Reading or Space which requires testing. This will begin the test, applying the conditions previously set (% Stability, Test Current etc.).

NOTE: Test Method 3 cannot validate 'Make Before Break' operation of OLTC tap changers because test current is discharged between each test. Test Wizard (Method 1) is required for proper OLTC validation.

Resistance Test Screen

Once a test sequence begins from Method 1-3 above, the following screen will appear:



i. **Test Setup:** Allows changes to test parameters, which can be seen in Item iv above (and described in Item iv below). This button is 'greyed out' once testing begins or MTO instrument connection is not established.

ii. **Test Mode:** Enables various testing to Start, Continue, Save Results etc. as testing is conducted. This button guides operator through testing, providing instruction for next steps.

iii. **Abort/Exit:** Allows disruption of test and/or exiting once test is concluded.

iv. **Test Setup Settings:** Display settings from Item i above for operator review.

v. **Results Graph:** Plots resistance results for diagnostic review. This is useful in determining that each past result is following an expected pattern. Different OLTC tap changers develop different shaped patterns such as V, Saw Tooth, Slope curves. Familiarity with these tap changers helps improve diagnostic capability.

vi. **Measured Resistance:** Result with color background changes using Reading Stability and Time for Stable Reading settings as shown in Item iv above. When condition is reached, background turns green.

vii. **Reading Stability:** Monitors readings, and calculates the change continuously, changing background color to green once Reading Stability Setting is reached.

7

SAVE/RETRIEVE RESULTS

While testing, it is critical that results are saved as testing is performed. In order to enable this ability, PowerDB automatically requests a file name each and every time a test result is obtained UNTIL such time as a file name is entered for the result. Once a name is given to the result, all results are saved into a file with this name as shown below. It should be noted here that a result file IS ALSO a test file. One is able to both view results as well as use this file to retest or append previous results.

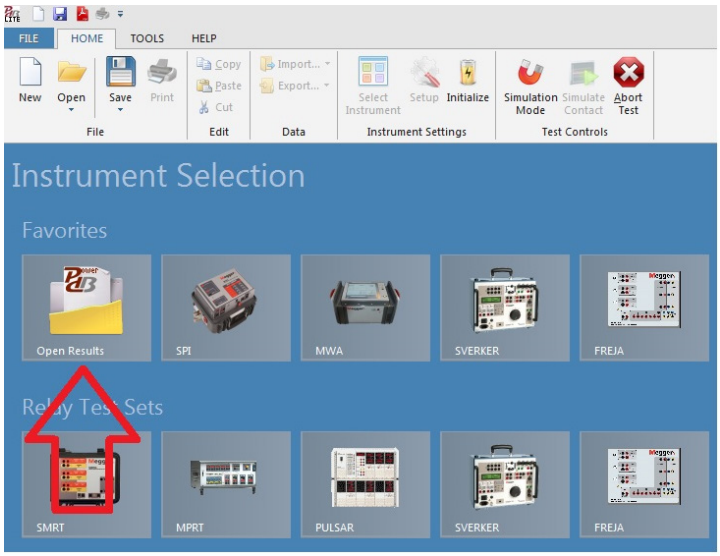
Above shows window which appears after first test is completed and after each result until file is given a name and saved.

After initial results are saved with a file name as per above, all testing results continue to be saved as testing is conducted.

In order to rename a test file (result) user has the option to save result under a different name, as a template or as a PDF (original test file remains unchanged). Results can be also printed by depressing print icon.

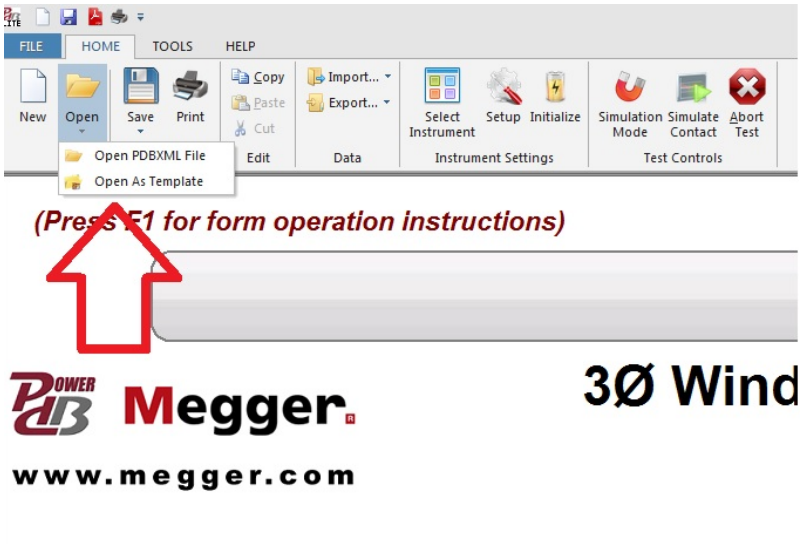
Retrieving Results/Test Files

There are 2 ways to retrieve results and or test files. In PowerDB, the result file is also the test file, which allows user to review results, append results or use result file as a template for new test. This feature makes retesting assets more efficient, more consistent, and easier to conduct testing for new users. Once a file is saved, user has the option to recall the result in numerous ways which are shown below:



Within the *Instrument Selection* window, user is able to open test file for results review, retesting asset or to append existing results.

Save/retrieve results



Once MTO instrument is selected, user can open saved result to view results and/or to retest/append results, or use present form as a template (once settings are entered into form).

8

APPLICATION NOTES

Testing Delta Configured Windings

Testing Delta winding resistance may be a very time consuming procedure, in particular LV winding deltas the correct balance time can take up to 30-60 minutes for a large transformer. The method for improving test time for delta configurations requires that both the high side and low side be connected in series with the MTO's current source (see connection Table 1). By using both HV and LV windings to magnetize the core, the effective test magnetization current increases with the turn ratio (simultaneous winding magnetization, SWM).

As an example, testing the Low Voltage side of a 100/10 kV Yd transformer with dual side injection at 10A is the same as testing only the Low Voltage side of that same transformer 68 A. Even if only one side of the transformer needs to be tested, connecting both high and low windings in series will speed the test up by a factor of 10 or more.

Delta Winding Resistance

Manufacturer's winding resistance data are usually presented as per winding for Y configurations and per terminal pairs for Delta windings. In the rare case that manufacturer's data is presented per winding also for a delta connection, the recommendation is to recalculate the numbers to terminal pairs and compare with the field measurement results.

Ravg = Average individual winding resistance

Rtp = Winding resistance between terminal pairs

Rtp=Ravg*0.6667

Temperature Correction

It may be necessasry to convert the resistance measurements to values corresponding to the reference temperature in the transformer test report.

To estimate the winding temperature at the time of measurement is important. There are three things needed to get the resistance readings corrected, Winding Material, Winding Temperature and Corrected to Temperature.

Temperature Entry

If the transformer has winding temperature meters, use theses readings. Most transformers will have a meter for each winding. Most meters are reading about the same value for a static transformer. Use the average of the three readings and place this number in the Winding Temp field of the Transformer nameplate section of the form. A secondary method is to use the oil temperature. Use this value in the winding temp field and oil temp field of the form.

Other information

- The transformer has been out of service for at least 3 hours
- The temperature of the insulating liquid has stabilized, and the difference between the top and bottom temperature does not exceed 5°C.

If the transformer is measured without oil, the winding temperature is normally assumed to be the same temperature as the surrounding air.

Once the information and results are in the form, the results can be switched from measured resistance to corrected

resistance using the checkmark in the transformer nameplate section.

Conversion of Resistance Measurements

Winding resistance measurements are normally converted to a standard reference temperature.

The conversions are accomplished by the following formula:

Rs = Rm (Ts + Tk)/(Tm + Tk)

where

Rs = resistance at desired temperature Ts

Rm = measured resistance

Ts = desired reference temperature

Tm = temperature at which resistance was measured

Tk = 234.5 (copper)

Tk = 225 (aluminum)

9

ORDERING INFORMATION / SPARE PARTS

Table 9-1 Replacement Parts List

ITEM	CAT. NO
Three-phase Transformer Ohmmeter Test Set, PC controlled Transformer Ohmmeter, PC Control only, 120V ±10% 230V ±10%, 47-63 Hz	MTO300
Three Phase Transformer Ohmmeter with On Board Controller, 120V ±10% 230V ±10%, 47-63 Hz	MTO330A

INCLUDED ACCESSORIES

Canvas carrying bag for test leads	2005-265
Universal AC power cord set, 2.5m (8 ft), IEC, includes US standard, Schuko CEE 7/7, BS1363, AS/NZ S3112:2004	2009-874
Ground Lead, 15 ft (4.5 m)	4702-7
USB Memory stick contains: PDF manual, PowerDB Lite software and related documents	1010-941

OPTIONAL ACCESSORIES

Universal lead sets, compatible with Megger MTO3XX Series products (up to 10 A DC max) 3-phase, 4-wire shielded test leads (H&X), complete with color coded universal Kelvin clamps

3-Ø shielded test lead set, X/H windings, 30 ft (9.1m)	2008-30-KIT
3-Ø shielded test lead set, X/H windings, 60 ft (18 m)	2008-60-KIT
3-Ø shielded test lead set, X/H windings, 100 ft (30m)	2008-100-KIT
3-Ø 33 ft (10 m) Extension, X lead set	36486-7
3-Ø 33 ft (10 m) Extension, H lead set	36486-8
3-Ø 33 ft (10 m) extension, H&X windings	36486-9
3-Ø Universal, 9 m (30 ft) H	2008-113-30

ITEM

3–Ø Universal, 9 m (30 ft) X	2008-114-30
3–Ø Universal, 18 m (60 ft) H	2008-113-60
3-Ø Universal, 18 m (60 ft) X	2008-114-60
3-ø Universal, 30 m (100 ft), H	
3-ø Universal, 30 m (100 ft), X	2008-113-100
2008-114-100	
Resistance Test Shunt, 10 A, 10 mΩ	1006-512-2
MTO300/330A Mains Fuse (2x)	90001-167
Transit case for instrument leads and accessories	2005-340
Remote tap controller, manual operation, model RTC-1, complete with quick guide, and red/black/white (total 3) alligator clips	1007-502

10

SERVICE

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 required for the MTO test set.

The appearance of the MTO test set can be maintained by occasionally cleaning the case, panel and cable assemblies.

1. Clean the outside of the carrying case with detergent and water. Dry with a clean, dry cloth.
2. Clean the control panel 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. An all-purpose, household spray cleaner can be used to clean the panel. Polish with a soft, dry cloth, taking care not to scratch the display screen cover.
3. Clean the cables and mating panel receptacles with isopropyl or denatured alcohol applied with a clean cloth.
4. Inspect the cable assemblies occasionally to ensure they are in good condition.

Fuse Replacement

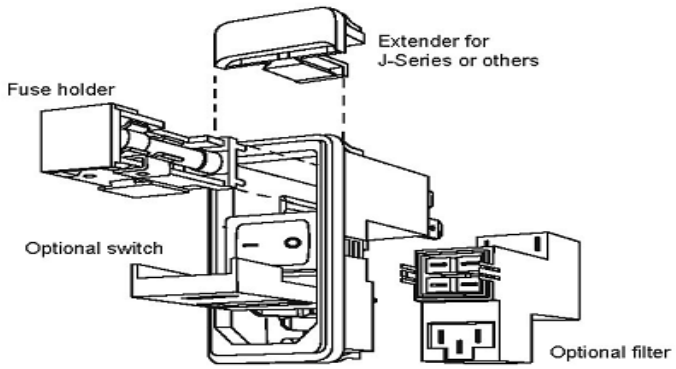
The electronic circuits in the MTO test set are protected by two mains fuses. Fuse replacement is indicated if the electronic circuits do not function. Refer any fuse replacement to qualified personnel. Please consult the manufacturer for proper replacement fuses to avoid electric shock and fire hazard. Note that 2 spare fuses are included with each MTO.

WARNING

Before replacing the fuses, disconnect the power input plug from the live power source.

To replace fuse(s), proceed as follows:

1. Disconnect the power cord from the MTO test set.
2. Using a small flathead screwdriver, carefully remove the fuse holder of the input power module installed on the right side of the MTO test set front panel.
3. Remove and properly dispose of blown fuse(s).
4. Install new fuse(s) making sure to use the type specified by the manufacturer.
5. Reinstall the fuse holder in its receptacle in the input power module. Connect the power cord to the MTO test set and to an energized power source. If the electronic circuits still do not function properly, contact the factory for service.



Calibration

A complete performance and calibration check should be made at least once every year. This will ensure that the MTO test set is functioning and calibrated properly over the entire measurement range. The MTO calibration is performed on each new or repaired unit before sending it to a customer. There is a special MTO final calibration procedure which requires a NIST-traceable test equipment to be used. As a result of such calibration procedure, each MTO test set may be NIST certified.

Repairs

Any service or repair of this equipment should only be performed by qualified persons who are aware of electrical hazards and the necessary precautions required to prevent injury.

Megger offers a complete Repair and Calibration Service and recommends that its customers take advantage of this service for routine maintenance or in the event of any equipment malfunction.

In the event that Service is required, contact your Megger representative for a product Return Authorization (RA) number and shipping instructions.

Ship the product prepaid and insured and marked for the attention of the Megger Repair Department. Please indicate all pertinent information, including catalog number, serial number, and problem symptoms.

Error Codes

MTO comes with a wide range of error codes to assure unit is working properly and track down problems in a systematic manner. When an error code occurs, the first thing to do is acknowledge the error by pressing enter and repeating the test. If the error persists, review the possible causes and determine if you can resolve the problem on site. If the basic cause is ruled out, contact Megger for additional assistance. Bold Error codes are quite common with the possible causes defined.

CODE	Error Description	Possible Cause
ESd	ESD is pushed down	Button is pushed down, internal cable is disconnected, internal hardware failure
IntLoc	Interlock interface is open (MTO210)	Interlock Jumper removed, attached interlock circuit broken, internal cable disconnected
1XX	Ethernet and top panel errors	
101	No link between top panel and lower acquisition board	

102	Ethernet communication failed	Check connection
110	Current selection switch error	
111	Function Mode switch error	
112	Storage Mode Switch errors	
113	I2C BUS error	
114	LCD I2C bus error	
115	LED I2C bus error	
116	MUX I2C bus error	
117	EEPROM failure	
2.0	Initialization error	
201	ADC internal zero calibration failure	
202	ADC internal full-scale calibration failure	
203	Onboard 5 volt supply out of range, too high	
204	Onboard 10 volt out of range, too high	
205	Onboard 28 volt out of range, too high	
206	VICOR power supply temperature is out of range	
207	Discharge circuit temperature is out of range	
208	2.5V reference is out of range	
209	Zero reference is out of range	
210	25V reference is out of range	
211	VICOR power supply failed to regulate at 5 volts	
212	VICOR power supply failed to regulate at 20 volts	
213	VICOR power supply failed to regulate at 40 volts	
214		
215	VICOR power supply control loop circuit failed	
216	Too much voltage ripple for the 5 volt supply	
217	Too much voltage ripple for the 10 volt supply	
218	Too much voltage ripple for the 28 volt supply	
221	Too much voltage ripple for the 2.5 volt reference	
222	Too much voltage ripple for the 25 volt reference	
223	Too much voltage ripple for the VICOR power supply at 5 volts	
224	Too much voltage ripple for the VICOR power supply at 20 volts	
225	Too much voltage ripple for the VICOR power supply at 40 volts	
226	UNDER status input failed	
227	OVER status input failed	
228	EEPROM byte writing error	
229	EEPROM byte reading error	
230	EEPROM is uninitialized	
231	Discharge temperature too much ripple	
232	5V5 voltage out of range	
233	5V5 voltage too much ripple	
234	VICOR power supply failed at 5v, voltage too high	
235	VICOR power supply failed at 5v, voltage too low	

236	VICOR power supply failed at 20v, voltage too high	
237	VICOR power supply failed at 20v, voltage too low	
238	VICOR power supply failed at 40v, voltage too high	
239	VICOR power supply failed at 40v, voltage too low	
240	VICOR power supply failed at loop test, voltage too low	
241	Onboard 10v out of range, voltage too low	
242	Onboard 28v out of range, voltage too low	
243	Discharge temperature is out of range, too high	Unit overheated, fans filters clogged, fans not working, overuse, extremely hot test conditions
244	VICOR temperature is out of range, too high	Unit overheated, fans filters clogged, fans not working, overuse, extremely hot test conditions
245	VNOISE voltage out of range, too low.	
246	VICOR temperature too much ripple	
3.0	ADC_ERROR	
301	ADC reading times out or ADC locks up	
302	Internal error. Communication with ADC failed.	
303	ADC sample rate setting failed	
304	ADC internal zero cal failed	
305	ADC internal full-scale calibration failed	
306	ADC cannot be restored back to normal mode	
307	ADC channel 1 selection failed	
308	ADC channel 2 selection failed	
309	ADC channel 3 selection failed	
310	Too much noise/ripple on ADC readings	
311	ADC failed, initialization	
312	ADC failed, run time	
313	ADC locks up, can not read	
314	ADC channel 4 failed	
4.0	HARDWARE_ERROR	
401	Discharge takes too much time	
402	VICOR protection failed, OVER is too long or too short to reset	
403	VICOR protection failed, OVER is too long or too short to set	
404	VICOR fast protection failed, OVER is too long or too short to reset	
405	VICOR fast protection failed, OVER is too long or too short to set	
406	Current Regulation failed at DAC=0	
407	Current Regulation failed at 10mA range	
408	Current Regulation failed at 100mA range	
409	Current Regulation failed at 1A range	
410	Current Regulation failed at 10A range	

411	Current output not high enough	
412	Too much ripple for Lamp On	
413	Too much ripple for Lamp Off	
414	Test Lamp voltage is too low	
415	Test Lamp voltage is too high	
416	Warning Lamp test failed	
417	Remote lamp test failed	
418	Relay test K1 on and K2 on failed	
419	Relay test K1 off test failed	
420	Relay test K2 off test failed	
421	Relay test K3 on and K4on failed	
422	Relay test K3 off test failed	
423	Relay test K4 off test failed	
465	OVER and UNDER failed during winding resistance test	
466	Current calibration failed during winding resistance test	
467	Voltage calibration failed during winding resistance test	
468	Received abort signal	
469	System zero cal failed during current regulation	
470	No current setting has been set for current control.	
471	Current is flat or dropping while charging	Current leads not connected
472	Break before make error	Lead removed during testing. >10% current change during testing.
473	H1+ failed, Vrelay3 failed	
474	X3+ failed, K9 failed	
475	I-SENSE failed	
476	Auto-range, resistance is too high	
477	Auto-range, current failed	
478	Auto-range, current standard deviation too high	
479	Auto-range, voltage is too low	
480	Current = 0	
481	Over didn't stay set for normal transistor protection test	
482	Over didn't stay set for fast transistor protection test	
483	Transistor protection med-low failed, OVER is too short to reset	
484	Transistor protection med-low failed, OVER is too short to set	
485	Fast transistor protection high failed, OVER is too short to reset	
486	Fast transistor protection high failed, OVER is too long to set	
487	Fast transistor protection high failed, OVER is too short to set	

488	Current Regulation failed at 10mA range, too low	
489	Current Regulation failed at 100mA range, too low	
490	Current Regulation failed at 1A range, too low	
491	Current Regulation failed at 10A range, too low	
492	Relay K1 and K2 failed, current too low	
493	Relay K3 and K4 failed, current too low	
494	ESD Abort signal encountered	Switch pushed down during test
496	Vicor failed during charge	
497	Current rising too fast during charge	
498	Charge timeout error.	

Megger

Manufacturing sites

Megger Limited
Archcliffe Road
Dover
Kent
CT17 9EN
ENGLAND
T. +44 (0)1 304 502101
F. +44 (0)1 304 207342

Megger GmbH
Weststraße 59
52074
Aachen
Germany
T. +49 (0) 241 91380 500
E. info@megger.de

Megger USA - Valley Forge
Valley Forge Corporate Center
2621 Van Buren Avenue
Norristown
Pennsylvania, 19403
USA
T. 1-610 676 8500
F. 1-610-676-8610

Megger USA - Dallas
4545 West Davis Street
Dallas
75211-3422
T. +1 214 333 3201
F. +1 214 331 7399
USsales@megger.com

Megger AB
Rinkebyvägen 19, Box 724,
SE-182 17
DANDERYD
T. 08 510 195 00
E. seinfo@megger.com

Megger Baker
4812 McMurry Avenue
80525
USA
T. +1 970-282-1200
E. baker.sales@megger.com

Part No: MTO3XXX-UG-EN-V01