MTO106

Transformer ohmmeter

User's Manual

Megger

WWW.MEGGER.COM

Art No. ZP-BN01E	Doc. BN034794AE	V01a	2018

MTO106

Transformer ohmmeter

User's Manual

Megger Sweden AB is certified according to ISO 9001 and 14001.

Postal address:
Megger Sweden AB
Box 724
SE-182 17 DANDERYD
SWEDEN

Visiting address:
Megger Sweden AB
Rinkebyvägen 19
SE-182 36 DANDERYD
SWEDEN

T +46 8 510 195 00
F +46 8 510 195 95

seinfo@megger.com
www.megger.com

CE

Contents

1 Introduction 6

1.1 Product description 6

Features and benefits 6

Applications 6

1.2 Winding resistance testing 6

1.3 Receiving instructions 7

1.4 Warranty 7

Warranty repair 7

2 Safety 8

2.1 General 8

Symbols on the instrument 8

2.2 Safety instructions 8

Maintenance 9

3 Instrument description and Accessories 10

3.1 Panel 10

3.2 The display 11

3.3 Accessories 11

Included 11

Optional 11

4 Setup and operation 12

4.1 Preparations 12

4.2 Testing Single and Dual windings 12

4.3 Testing Delta winding resistance 13

5 Application examples 14

5.1 Testing transformers with tap changers 14

5.2 Temperature correction 14

5.3 Manual demagnetization of a transformer 15

6 Troubleshooting and Calibration 16

6.1 Troubleshooting 16

7 Specifications 18

Specifications 18

1 Introduction

1.1 Product description

The MTO106 transformer ohmmeter is an easy-to-use, line-operated instrument specifically designed for safe and accurate field measurement of winding resistance in smaller transmission and distribution transformers.

It has dual channels with a wide measurement range and can accurately provide information about the vast majority of power transformers, reactors and instrument transformers. The test current can be manually set in five different ranges to fit transformers of various sizes.

The unit has built-in safety protection for testing transformers and other components with high inductance. To ensure operator safety, MTO 106 automatically discharges the stored energy in the transformer at the end of each test. If a current lead is disconnected while current is flowing through the transformer, the current will flow through the alternate path of the potential lead without damage to the instrument or risk to the operator

Features and benefits

- Test current up to 6 A and stable current generation
- Up to 48 V output voltage for fast charging of transformer windings
- Light weight and portable
- Very short start-up time
- Ease of use
- Resistance range, 10 µOhm to 30 kOhm, for testing a wide variety of transformers.

Applications

The MTO106 is mainly intended for field measurements of smaller transmission and distribution transformers:

- To verify factory test readings
- As part of a regular maintenance program.
- To help locate the presence of defects in transformers such as increased contact resistance in terminal connections and tap changers.

The instrument can also be used for general resistance measurements of for instance control wiring, voltage regulators, motors, generators and all types of connections.

1.2 Winding resistance testing

Transformer winding resistances are measured in the field in order to check for abnormalities due to loose connections, broken strands, and high-contact resistance in tap changers. Interpretation of results is usually based on a comparison of measurements made separately on each phase in the case of a wye-connected winding or between pairs of terminals on a delta-connected winding. Comparison may also be made with original data measured in the factory.

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

- Calculations of the I^2R component of conductor losses.
- Calculation of winding temperature at the end of a temperature test cycle.
- As a diagnostic tool for assessing possible damage in the field.

Problems or faults occur due to poor design, assembly, handing, poor environments, overloading or poor maintenance. Measuring the resistance of the windings 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. Any of the ratio changes involve a mechanical movement of a contact from one position to another. To tetect contact wear, winding resistance measurements are usually performed at each tap in a load tap changer.

1.3 Receiving instructions

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

1.4 Warranty

Products supplied by Megger are warranted against defects in material and workmanship for a period of one year following shipment.

Our liability is specifically limited to replacing or repairing, at our option, defective equipment.

This warranty does not include batteries, lamps or other expendable items, where the original manufacturer's warranty shall apply.

We make no other warranty. The warranty is void in the event of negligence abuse (failure to follow recommended operating procedures) or failure by the customer to perform specific maintenance as indicated in this manual.

Warranty repair

- Equipment returned to the factory for repair must be shipped prepaid and insured.
- Contact your Megger representative for instructions and a return authorization (RA) number.
- Indicate all pertinent information, including problem symptoms.
- Specify the serial number and the catalog number of the unit.
- If you need to return the instrument, please use either the original crate or one of equivalent strength.

2 Safety

2.1 General

For your own safety and to get the maximum benefit from your instrument, please ensure that you read and understand the following safety instructions and warnings before using the instruments.

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

Symbols on the instrument

Caution, refer to accompanying documents.

Protective conductor terminal.

WEEE, Waste Electrical and Electronic Equipment. Please utilize your local WEEE collection facilities in the disposition of this product and otherwise observe all applicable requirements.
The unit can also be returned to Megger at any time at no charge for the disposal.

2.2 Safety instructions

1.	**Single ground system** - This equipment can be used only in electrical systems with single ground. Before connecting this unit to power you must verify that High Voltage Ground and Low Voltage Protective Ground create a single protective ground with no measurable voltage potential existing between these ground systems. If a voltage potential is found between the ground systems please consult local safety regulations.
2.	**Mains cord protective conductor** - The instrument is equipped with a power cord with integral safety ground pin. Do not defeat the safety ground in any manner. The equipment must be connected to a grounded mains outlet.
3.	**Ground lead** - The first connection made, and last removed is the connection of instrument Protective conductor terminal to station ground using the separate ground lead. Make sure ground lead is checked for continuity and securely fastened.
4.	**Use an easily accessible power outlet** - This will ensure that you can disconnect the power quickly in case of a problem. The instrument should be operated only from the type of power source indicated on its nameplate.
5.	**Connecting** - It is very important not to connect any leads on top of or too close to one another. Take the necessary precautions to as-sure one lead falling off will not take a second lead with it. Never connect the test equipment to energized equipment. Never make any connection or disconnections while the test equipment is generating or discharging.
6.	**Testing** - When applying current to a transformer with very high inductance, additional care should be taken not to remove current leads while current is still flowing. Removal of terminals while current flowing may generate an arc that may result in lethal injury: electrical, thermal or by fall. 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.

7.	**Water and moisture** - Do not use the instrument near water. To prevent fire or shock hazard, do not expose the instrument to rain or moisture. Do not touch the plug with wet hands
8.	**Ventilation** - Slots and openings in the instrument are provided for ventilation. They ensure reliable operations of the instrument, keeping it from overheating. These openings must not be blocked nor covered during operation.
9.	**Accessories** - Do not use any accessories that are not intended for use together with the instrument.

Maintenance

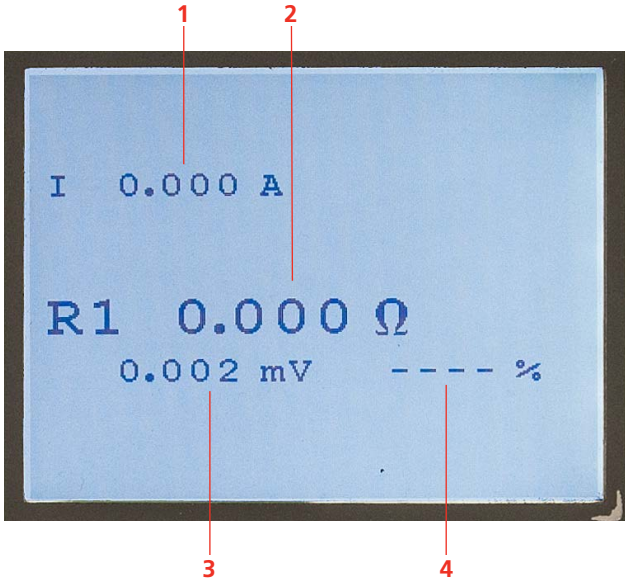
1.	**DISCONNECT the MAINS** plug before any cleaning or maintenance.
2.	**Refer all servicing** to Megger authorized personnel. Do not attempt to service the instrument yourself. If you attempt to service the instrument the warranty is no longer valid.
3.	**Read and understand Safety** in the User Manual before performing any service.
4.	**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.
5.	**Cleaning** - Use a damp cloth for cleaning. Do not use liquid cleaners or aerosol cleaners.

3 Instrument description and Accessories

3.1 Panel

1. **R1 SENSE**
   R2 SENSE
   Voltage input
2. **CURRENT OUTPUT**
   1 mA - 6 A, 48 VDC
   Current output
3. **R2 SENSE**
   Switch for selection of single/dual channel measurement. Dual channel measurement is active when the switch is in the “ON”position.
4. **Touchscreen**
   4 inch, backlit, monochrome display
5. **DISCHARGE**
   Built-in discharge circuit safely discharges the test object when test is completed. LED and audio signal indicate the charging status.
6. **100-240 V ~ 5 A**
   50 / 60 Hz
   Mains input and fuse box: Always use the power cord supplied with the unit. The unit is powered when the switch for power input is in the “on” position.
7. **RANGE**
   Selector for test currents.
8. **ON/OFF**
   Toggle switch ON/OFF for generation of test currents. Red Indicator lamp lit during generation.
9. ⏚
   Protective conductor terminal: To be connected to station earth (ground) using separate ground lead, see "2.2 Safety instructions" on page 8.

3.2 The display



1. Injected current. The current value displayed may differ slightly from the selected current.
2. Measured resistance value. The value is typically displayed with four significant digits. If fewer digits are displayed, it is recommended to lower the test current.
3. Voltage measured over the "R1 SENSE" connectors. This voltage is divided by the injected current to calculate the resistance reading.
4. Stability reading. Reaches 100% when the measurement is stable.
   Note: In large transformers the MTO106 may be unable to fully saturate the core and the reading may approach 100% only very slowly.

Note *If dual channel measurement is selected, the above values are duplicated.*

3.3 Accessories

Included

Test lead black with banana connector and Kelvin clamp, 10 m (33 ft)	1	GC-32310
Test lead red with banana connector and Kelvin clamp, 10 m (33 ft)	1	GC-32312
Ground lead, 5 m (16 ft) 2.5 mm²	1	GA-00200
Mains cable	1	AA-00010
User's manual	1	ZP-BN01E
MTO106 Report pad	1	XP-BN01E
MTO106 Reporting template file	1	SB-0022E
Carry bag	1	2000-091


GC-32310


GC-32312


GA-00200

2000-091

Optional

Transport case for instrument and leads	1009-744
MTO106 dual channel measurement lead set	GA-19000

Parts included in the MTO106 dual channel measurement lead set (GA-19000).

Sensing lead, black, 10 m (33 ft)	1	KG-00530
Sensing lead, red, 10 m (33 ft)	1	KG-00532
Timing clamp	2	KD-03040
Test cable, black, 2 m (6.5 ft)	1	04-35030


1009-744


KG-00530


KG-00532


KD-03040

4 Setup and operation

4.1 Preparations

Important
Always follow the safety instructions in Chapter 2 of this manual. Always comply with local safety regulations.

- Use the Megger supplied safety ground lead to connect the MTO106 protective conductor terminal directly to local station earth (Ground).

Note *If using separate voltage and current leads instead of the standard Kelvin-type leads, do not clip potential leads on to the current leads, since this will add contact resistance to the measurement. Potential leads should always be placed inside (between) current leads*

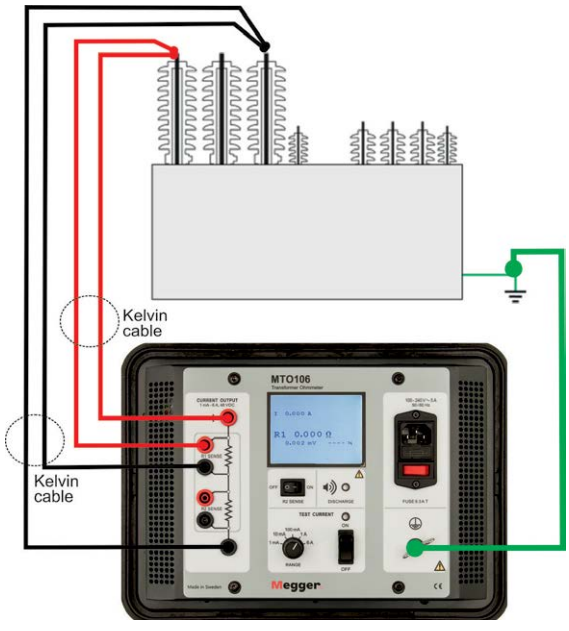
4.2 Testing Single and Dual windings

1] Make sure that the test current switch is set to "OFF".

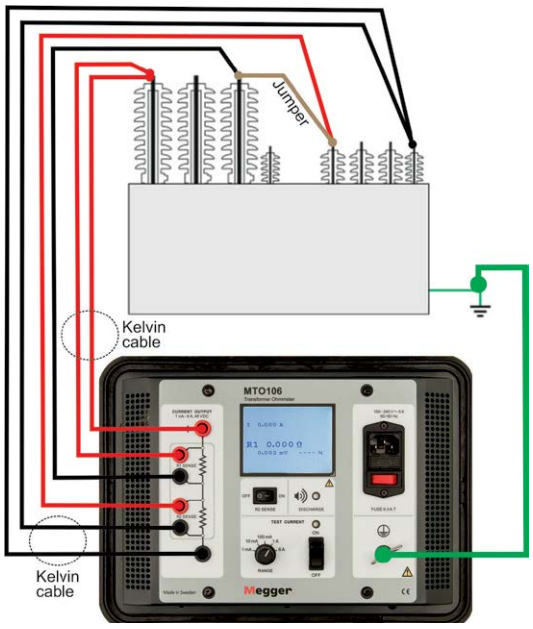
2] Connect the Kelvin-type test leads to the MTO106, see figures below.
The leads marked "Generator" to the "CURRENT OUTPUT" terminals of corresponding colour and the leads marked "P/Meas" to "R1 SENSE" terminals of corresponding colour.
If using separate voltage (sense) and current leads, connect them to the corresponding "CURRENT OUTPUT" and "R1 SENSE" terminals.
For Dual windings:
Connect the second channel sense leads to the terminals "R2 SENSE" of corresponding colour.
Use a jumper cable to connect two phases (according to table 1 on next page) for simultaneous winding measurement.

3] Connect the test lead Kelvin clamp to the test object (e.g. transformer) according to the required configuration.

4] Once all the precautions and steps of sections "2 Safety" on page 8 and "4.1 Prepara-



Connection diagram for single winding test.



Connection diagram for dual winding test.

tions" on page 12 are complete, the mains power cord is connected to the power outlet.

5] Set the "RANGE"selector to the required test current, as high as possible but not more than 10% of rated current (power transformers, reactors, rotating machines). For a CT, preferably use 1 A.

6] **For Single winding**
Set switch "R2 SENSE" to "OFF" position.
For Dual windings:
Set switch "R2 SENSE" to "ON" position.

7] Set switch "TEST CURRENT" to "ON", to initiate current.

8] The current and resistance values must be observed on the display. Wait for the stability reading to reach 100% and then note the displayed resistance value in the supplied reporting sheet or other location.

9] When the measurement is finished set the "TEST CURRENT" switch to "OFF".
The "DISCHARGE" lamp and sound will indicate that the discharging is in progress.

10] Discharge is complete when both discharge indicator and "TEST CURRENT" lamp are off.

Warning
Do not disconnect any test leads until the "DISCHARGE" light goes out and the sound stops.

Note *The discharge of a transformer after testing is critical to prevent excessive voltage build-up across the transformer bushings upon removal the test leads. The MTO106 discharge circuitry is built-in and will automatically initiate when the current source is disconnected from the transformer. It will also provide visual and audible indication of discharging.*

4.3 Testing Delta winding resistance

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, which far exceeds the time restriction of many tests.

The method for quickly testing delta configurations requires that both the high side and low side be connected in series with the Transformer Ohmmeter's current source (see connection table 1). By using both HV and LV windings to magnetize the core, the effective test current increases with the turn ratio.

Table 1. Transformer connection schemes for injecting test current and measuring two windings

Vector Group	*Measurement setup*						
	Current Connections			*Meas ch 1*		*Meas ch 2*	
	+ Current	*Jumper*	*- Current*	+	-	+	-
Dd0	H1	H3-X1	X3	H1	H3	X1	X3
	H2	H1-X2	X1	H2	H1	X2	X1
	H3	H2-X3	X2	H3	H2	X3	X2
Dyn7	H1	H3-X0	X1	H1	H3	X0	X1
	H2	H1-X0	X2	H2	H1	X0	X2
	H3	H2-X0	X3	H3	H2	X0	X3
Dyn1	H1	H3-X1	X0	H1	H3	X1	X0
	H2	H1-X2	X0	H2	H1	X2	X0
	H3	H2-X3	X0	H3	H2	X3	X0
YNyn0	H1	H0-X1	X0	H1	H0	X1	X0
	H2	H0-X2	X0	H2	H0	X2	X0
	H3	H0-X3	X0	H3	H0	X3	X0
Ynd1	H1	H0-X1	X2	H1	H0	X1	X2
	H2	H0-X2	X3	H2	H0	X2	X3
	H3	H0-X3	X1	H3	H0	X3	X1
Dy1	H1	H3-X1	X2	H1	H3	X3	X2
	H2	H1-X2	X3	H2	H1	X1	X3
	H3	H2-X3	X1	H3	H2	X2	X1
YNd7	H1	H0-X2	X1	H1	H0	X2	X1
	H2	H0-X3	X2	H2	H0	X3	X2
	H3	H0-X1	X3	H3	H0	X1	X3
Dyn5	H1	H2-X0	X1	H1	H2	X0	X1
	H2	H3-X0	X2	H2	H3	X0	X2
	H3	H1-X0	X3	H3	H1	X0	X3
Dy11	H1	H3-X1	X3	H1	H3	X1	X3
	H2	H1-X2	X1	H2	H1	X2	X1
	H3	H2-X3	X2	H3	H2	X3	X2
Dyn11	H1	H2-X1	X0	H1	H2	X1	X0
	H2	H3-X2	X0	H2	H3	X2	X0
	H3	H1-X3	X0	H3	H1	X3	X0

5 Application examples

5.1 Testing transformers with tap changers

The tap changer allow ratio to be increased or decreased. Any of the ratio changes involve a mechanical movement of a contact from one position to another. It is this contact that needs to be checked by way of its resistance. The contact may go bad for a number of reasons.

- Misaligned when manufactured causing insufficient surface contact. Full load current overheats contact surface causing it to burn.
- Current passing through contact exceeds full load rating.
- Load tap changing operation not "Make before break" creating internal arcing of contact surface.

Winding resistance measurements (WRM) are normally performed for every tap the same way as WRM for individual windings. The test instrument is continuously injecting test current and the resistances for each tap are measured sequentially as the tap changer is stepped through its positions. Results are typically presented as a graph or table with resistance values for each tap. Resistance changes between taps should be consistent with only small deviations between different tap position changes. Fig 1 shows a typical behavior for a transformer/tap-changer in as-new condition.

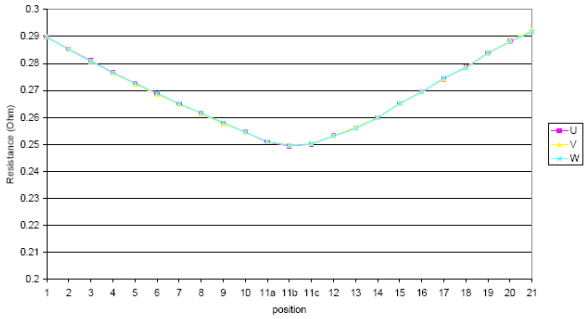


Fig 5.1. Winding resistance vs tap position for a new transformer

Measuring the winding resistance for each individual tap is quite straightforward. The most common issue is probably that the tester has not waited for a sufficient time for taking measurements after a tap change. Monitor the resistance value closely before storing the value to make sure the resistance value has stabilized!

5.2 Temperature correction

Cold winding resistance measurements are normally converted to a standard reference temperature equal to the rated average winding temperature rise plus 20°C. In addition, it may be necessary to convert the resistance measurements to the temperature at which the impedance loss measurements were made. If winding resistances are to be compared to factory values, resistance measurements will have to be converted to the reference temperature used at the factory (usually 75°C). 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, in °C.
Tm	temperature at which resistance was measured, in °C.
Tk	235 (copper) 225 (aluminum)

5.3 Manual demagnetization of a transformer

The MTO106 does not include and automated demagnetization feature and demagnetization, if deemed necessary, must be performed manually according to the method below.

1] Run a normal winding resistance test according to the instructions in section "4.2 Testing Single and Dual windings" on page 12.

2] Swap the terminals, preferably by swapping the Kelvin clamps, select the next lower test current and inject current until the current reading has reached at least 50% of the set value.

3] Repeat step 2 for each test current range down to the lowest selectable test current value.

6 Troubleshooting and Calibration

6.1 Troubleshooting

Resistance value	Voltage value	Current value	Probable cause	Action
"----" is displayed	U < 0.06 mV	Close to set value	1. Too low test current 2. Sense leads switched 3. Sense leads not connected 4. Current leads shorted	1. Increase test current 2. Check sense leads 3. Check sense leads 4. Check current leads
	U < 0.06 mV	0.0 A	No current loop, current leads not properly connected	Check current leads
	U > 20 V	Typical less than 50% of set current value	Too high test current	Lower test current
"< 0.010 mΩ" is displayed			Resistance below measurement range	
"< 0.10 mΩ" "< 1.0 mΩ" "< 0.010 Ω" or "< 0.10 Ω"			Too low test current	Increase test current

7 Specifications

Specifications

Specifications are valid at nominal input voltage. Specifications are subject to change without notice.

Environment

Application field	The instrument is intended for use in high-voltage substations and industrial environments.
Temperature	
Operating	-20°C to +50°C (-4°F to +122°F)
Storage & transport	-50°C to +70°C (-58°F to +158°F)
Humidity (operating)	0% – 90% RH, non-condensing

CE-marking

LVD	2014/35/EU
EMC	2014/30/EU
RoHS	2011/65/EU

General

Mains voltage	100-240 V AC, 50/60 Hz
Input power	400 VA (max)
Case	Ruggedized plastic case with removable lid and carrying handle, IP 67 when closed
Dimensions (W x D x H)	360 x 304 x 194 mm (14.2 x12 x 7.6")
Weight	7.3 kg (16 lbs) excl. cables
Display	4-inch, backlit, monochrome alphanumerical display
Test leads	2 x 10 m (33 ft), with banana connectors and Kelvin clamps
Ground lead	1 x 5 m (16 ft), 2.5 mm²

Measurement section

Measurment range	10 µOhm to 30 kOhm
Resolution	Up to 4 digits
Open circuit test voltage	up to 48 V DC
Measurement voltage	up to 20 V DC

Current range	Resistance range	Inaccuracy	Resolution
6 A	10.00 mΩ to 5.000 Ω	±(0.25%rdg + 1 digit)	4 digits
	0.010 mΩ to 9.999 mΩ	±(0.25%rdg + 2 digits)	0.001 mΩ
1 A	100.0 mΩ to 30.00 Ω	±(0.25%rdg + 1 digit)	4 digits
	0.10 mΩ to 99.99 mΩ	±(0.25%rdg + 2 digits)	0.01 mΩ
100 mA	1.000 Ω to 300.0 Ω	±(0.25%rdg + 1 digit)	4 digits
	1.0 mΩ to 999.9 mΩ	±(0.25%rdg + 2 digits)	0.1 mΩ
10 mA	10.00 Ω to 3000 Ω	±(0.25%rdg + 1 digit)	4 digits
	0.010 Ω to 9.999 Ω	±(0.25%rdg + 2 digits)	0.001 Ω
1 mA	100.0 Ω to 30.00 kΩ	±(0.25%rdg + 1 digit)	4 digits
	0.10 Ω to 99.99 Ω	±(0.25%rdg + 2 digits)	0.01 Ω

Your "One Stop" Source for all your electrical test equipment needs

- Battery Test Equipment
- Cable Fault Locating Equipment
- Circuit Breaker Test Equipment
- Data Communications Test Equipment
- Fiber Optic Test Equipment
- Ground Resistance Test Equipment
- Insulation Power Factor (C&DF) Test Equipment
- Insulation Resistance Test Equipment
- Line Testing Equipment
- Low Resistance Ohmmeters
- Motor & Phase Rotation Test Equipment
- Multimeters
- Oil Test Equipment
- Portable Appliance & Tool Testers
- Power Quality Instruments
- Recloser Test Equipment
- Relay Test Equipment
- T1 Network Test Equipment
- Tachometers & Speed Measuring Instruments
- TDR Test Equipment
- Transformer Test Equipment
- Transmission Impairment Test Equipment
- Watthour Meter Test Equipment
- STATES® Terminal Blocks & Test Switches
- Professional Hands-On Technical and Safety Training Programs

Megger is a leading global manufacturer and supplier of test and measurement instruments used within the electric power, building wiring and telecommunication industries.

With research, engineering and manufacturing facilities in the USA, UK, Germany and Sweden, combined with sales and technical support in most countries, Megger is uniquely placed to meet the needs of its customers worldwide.

Megger is certified according to ISO 9001 and 14001. Megger is a registered trademark.

Megger Group Limited
UNITED KINGDOM
Dover, Kent CT17 9EN
ENGLAND

- AUSTRALIA
- BULGARIA
- CANADA
- CZECH REPUBLIC
- CHINA
- FRANCE
- GERMANY
- HUNGARY
- INDIA
- INDONESIA
- KINGDOM OF BAHRAIN
- KOREA
- MALAYSIA
- PAKISTAN
- PHILIPPINES
- POLAND
- ROMANIA
- RUSSIA
- SINGAPORE
- SLOVAK REPUBLIC
- SOUTH AFRICA
- SPAIN
- SWEDEN
- SWITZERLAND
- TAIWAN
- THAILAND
- UNITED ARAB EMIRATES
- USA
- VIETNAM

CE

Megger®

WWW.MEGGER.COM

Postal address:
Megger Sweden AB
Box 724
SE-182 17 DANDERYD
SWEDEN

Visiting address:
Megger Sweden AB
Rinkebyvägen 19
SE-182 36 DANDERYD
SWEDEN

T +46 8 510 195 00
F +46 8 510 195 95

seinfo@megger.com
www.megger.com

Subject to change without notice. Printed matter No. ZP-BN01E | Doc. BN034794AE | V01a | 2018