

## Transformer Testing Equipment







# Leaders in Transformer Testing

■ **1895** - First insulation test set invented by Sydney Evershed

■ **1903** - Megger trademark registered

■ **1950** - Hand Crank Step Up ratiometer patented

■ **1965** - First low-weight tan delta/power factor insulation test set

■ **1980** - First transformer ohmmeter with tap-changer discontinuity detection

■ **1991** - Merger of the Megger Group (Megger, Biddle, Multi-Amp)

■ **1995** - First dynamic resistance measurements for on-load tap-changers

■ **1997** - First dielectric frequency response analyzer for insulation diagnostics in the field

■ **2009** - First portable 30 kV insulation test set

■ **2010** - Megger patent on individual temperature correction of measured tan delta/power factor values

■ **2010** - Megger patent on automatic detection of tan delta/power factor voltage dependence

■ **2013** - First 5 kV and 10 kV insulation resistance tester with 4 mA noise rejection and firmware filtering

■ **2014** - First 15 kV insulation resistance tester with 8 mA noise rejection and 5% accuracy up to 3 TΩ

■ **2015** - First multi-function transformer and substation test system with apps-based user interface

The first insulation test set "Megaohm meter" was invented by Sydney Evershed (Evershed & Vignoles Limited). The Megaohm meter was branded as "Megger" in 1903.

Since branding, Megger has grown and evolved to become the leading manufacturer of portable substation testing equipment. Insulation testing and the word 'Megger' are synonymous in the electrical test industry, a position only maintained by continually designing world class products.



Sydney Evershed's Megaohm meter (1895).

## Asset management plan

Transformers have the single highest value of the equipment installed in substations reaching 60% of the total investment. Asset managers are constantly under pressure to improve the financial and technical performance of transformers, which has pushed utilities to assess the actual condition of their transformers. Condition assessment contributes to achieving the optimal balance between maintenance costs and operating performance and provides asset managers the economic and technical justifications for engineering decisions and capital replacement plans.

Maintenance strategy and condition assessment actions differ from utility to utility but the well-accepted tests that are useful as diagnostic methods are listed in the table (overleaf).

## Complete testing toolbox

There are several facets to a transformer's overall health, so a full assessment requires a number of tests. Megger offers a broad range of transformer test equipment in the industry, capable of delivering the most comprehensive picture of transformer health.

Our instruments enable routine and advanced electrical testing techniques described and recommended in international standards such as IEEE, IEC and CIGRE. Moreover, our instruments and software tools are user-friendly, highly accurate and reliable to facilitate the management of your entire electrical testing program for power, distribution and instrument transformers.



Product selection guide

TEST TYPES		MEGGER TEST SETS															POWER DIAGNOSTIX TEST SETS			
COMPONENT	TEST	S1/MIT	DLRO	DELTA	IDAX	CDAX	OTD	OTS	TTRU3	MTO	MWA	FRAX	MLR10	TTV	TRAX	MRCT	ICMsystem	ICMcompact	ICMmonitor	
Windings	Resistance									■	■			■	■					
	Ratio / polarity			■		■			■		■			■	■					
	Excitation current			■	■				■		■			■	■					
	Short-circuit impedance												■	■	■					
	Frequency response analysis											■		■						
	FRSL													■	■					
	Insulation resistance	■			■									■						
	Capacitance	■		■	■	■								■	■					
	Power factor / tan delta			■	■	■								■	■					
	Narrowband Dielectric Frequency Response			■	■									■	■					
	Dielectric frequency response				■									■						
	Magnetic balance								■		■			■	■					
	Moisture content				■									■						
	Partial Discharge													■			■	■	■	
Bushings	Capacitance			■	■	■								■	■					
	Power factor / tan delta			■	■	■								■	■					
	Narrowband Dielectric Frequency Response			■	■									■	■					
	Dielectric frequency response				■									■						
	Bushing CT's													■	■	■				
	Partial Discharge													■			■	■	■	
Insulating oil	Dielectric strength							■						■						
	Power factor / tan delta			■	■		■							■	■					
	Temperature control power factor, resistivity and relative permittivity						■							■						
	Conductivity				■									■						
Tap changers	On-Load/ OLTC	Resistance								■	■			■	■					
		Ratio / Polarity			■					■		■			■	■				
		Excitation current			■	■				■		■			■	■				
		Contact timing / Dynamic resistance													■	■				
		Continuity (make before break)									■	■			■	■				
		Partial Discharge													■			■		■
	No-load/ DETC	Resistance									■	■			■	■				
		Ratio / Polarity			■					■		■			■	■				
		Excitation current			■	■				■		■			■	■				
Partial Discharge													■			■	■	■		
Core / Tank	Core insulation	■			■									■						
	Excitation current			■	■				■		■			■	■					
	Magnetic balance								■		■			■	■					
	Frequency response analysis											■		■						
	Ground connection		■											■	■					
Connections	Contact resistance		■							■	■			■	■					
Page number		6	7	8	10	12	13	14	15	16	17	19	20	21	22	24	28	28	29	

Transformer testing equipment

Megger provides thoughtfully equipped advanced transformer test instruments for commissioning, routine and diagnostic needs.

There are several design characteristics (dielectric, mechanical, electro-magnetic and thermal) and internal or external components in a power transformer which require specific testing procedures to assess transformer's overall health. Every single test in an individual component has characteristic strengths. Therefore, the individual tests are complementary one to each other and together provide a more robust representation of the component's health.

Many of the electrical field tests appearing in these suggested groups provide assessment information for several transformer components at once. So when the individual component test lists are merged, a thoughtful and overall smart test recommendation for transformers emerges. As some transformer tests are better suited as commissioning and diagnostic tests, the reason for testing (e.g., commissioning, routine screening and diagnostic test situations) will influence the electrical test recommendation for transformers.

Transformers should be tested periodically through their lifetime. However, limitless testing is not a good use of budget and manpower and not necessary. Some tests are well suited as screening tools while others make sense only under suspicion of specific problems.



# S1 and MIT Series

## High current insulation resistance tester



- Insulation testing up to 15 kV
- Resistance range up to 30 TΩ
- Operate from rapid charge Li-ion battery or AC source
- Advanced memory with time/date stamp
- Unique tough dual-case design providing additional user protection
- Safety rated up to CAT IV - 1000 V up to 4000 m altitude
- Stable readings in noisy environments



S1 and MIT Series high current insulation testers are ideal for transformer testing, cable, generator/motor, circuit breaker and general purpose testing. The products, depending on model, are packed with features such as IR, timed IR, polarisation index, dielectric absorption ratio and more. The models include rapid charge batteries and operation from an AC source when the battery is dead.

The S1 Series offers class leading charge current, noise rejection and software filters, making them Megger's most advanced DC insulation resistance testers to date.

Test reports can be created using test data by downloading information from the instrument memory or charts from real-time data. A range of high voltage test lead options are available with large or medium clips and in lengths 3 to 15 m depending on model.

S1 AND MIT SPECIFICATIONS	MIT515	MIT525	MIT1025	MIT1525	S1-568	S1-1068	S1-1568
Maximum test voltage	5000 V	5000 V	10000 V	15000 V	5000 V	10000 V	15000 V
Maximum test current	3 mA	3 mA	3 mA	4 mA	6 mA	6 mA	6 mA
Noise rejection	3 mA	3 mA	3 mA	4 mA	8 mA	8 mA	8 mA
PC Remote control & Bluetooth®					■	■	■
Step voltage, ramp & DD tests		■	■	■	■	■	■



# DLRO10HD

## Low resistance measurements



- Heavy duty micro ohmmeter
- High or low output power selection for condition diagnosis
- 10 A for 60 seconds, less time waiting to cool, great for charging inductance
- High input protection to 600 V for protection of inadvertent connection to line or UPS voltage

The DLRO 10HD measures resistance values up to 250 mΩ making it ideal for measuring connections, bonds and welds.

The heavy duty DLRO10HD low resistance ohmmeter combines rugged construction with accuracy and ease of use. The unit is powered from either its rechargeable battery or line power making it suitable for continuous testing in production line/repetitive use environments

The DLRO10HD is rated CATIII 300 V and it comes with a rugged IP65 case designed for stable ground and bench operation.

### DLRO10HD SPECIFICATIONS

Maximum test current	10 A
Test modes	Automatic Bidirectional Unidirectional Inductive
Measurement range	0.1 $\mu\Omega$ to 2500 $\Omega$
Power source	Mains/rechargeable battery
Battery life	> 1000 Auto (3 sec) tests
Weight	6.7 kg
Test leads	Duplex hand-spikes with indicators



# DELTA Series

## Tan delta / power factor test set



- Detect emerging insulation problems with Narrowband DFR (1-500Hz)
- Accurate measurements in high noise and HV environments
- Lightweight two-piece design, 14 kg and 22 kg
- Patented Individual Temperature Correction (ITC)
- User-friendly manual control

The DELTA 4000 Series is a fully automatic 12 kV insulation power factor/dissipation factor (tan delta) test set designed for condition assessment of electrical insulation in transformers, bushings, surge arresters, and other HV substation equipment. Additionally, Narrowband DFR (NB DFR) measurements can be made from 1 - 500 Hz, providing for a more accurate interpretation of tan delta/power factor test results and earlier detection of emerging insulation problems.

The DELTA 4000 Series can be used to measure the excitation current of transformer windings as well as to perform automatic tip-up tests for dry type transformers and HV turns-ratio testing (using an optional HV TTR capacitor) .

This state of the art instrument utilizes a patented method for temperature correction (ITC) versus now invalidated temperature correction tables. Additionally, the measurement is monitored and when a possible voltage dependency is detected, the user is prompted to perform tan delta/power factor tip-up measurements.

The DELTA 4110 requires an external computer to control it. The DELTA 4310A comes with an industrial controller designed to be viewable in sunlight but can also be controlled externally.

### DELTA SPECIFICATIONS

Input Power	100-240 V $\pm$ 10 %, 50/60 Hz, 16 A max
Output Voltage	0 to 12 kV
Test Frequency Range	1 to 500 Hz
Output Power	3.6 kVA
Output Current	300 mA (instantaneous)
Weight	14 kg + 22 kg = 36 kg

### MEASURING RANGES

Capacitance:	0 to 100 $\mu$ F
Inductance:	6H to 10 MH
Watt loss:	0 to 2000 W

### ACCURACY

Capacitance:	$\pm$ (0.5% of reading + 1 pF)
PF & DF:	$\pm$ (0.5% of reading + 0.02%)

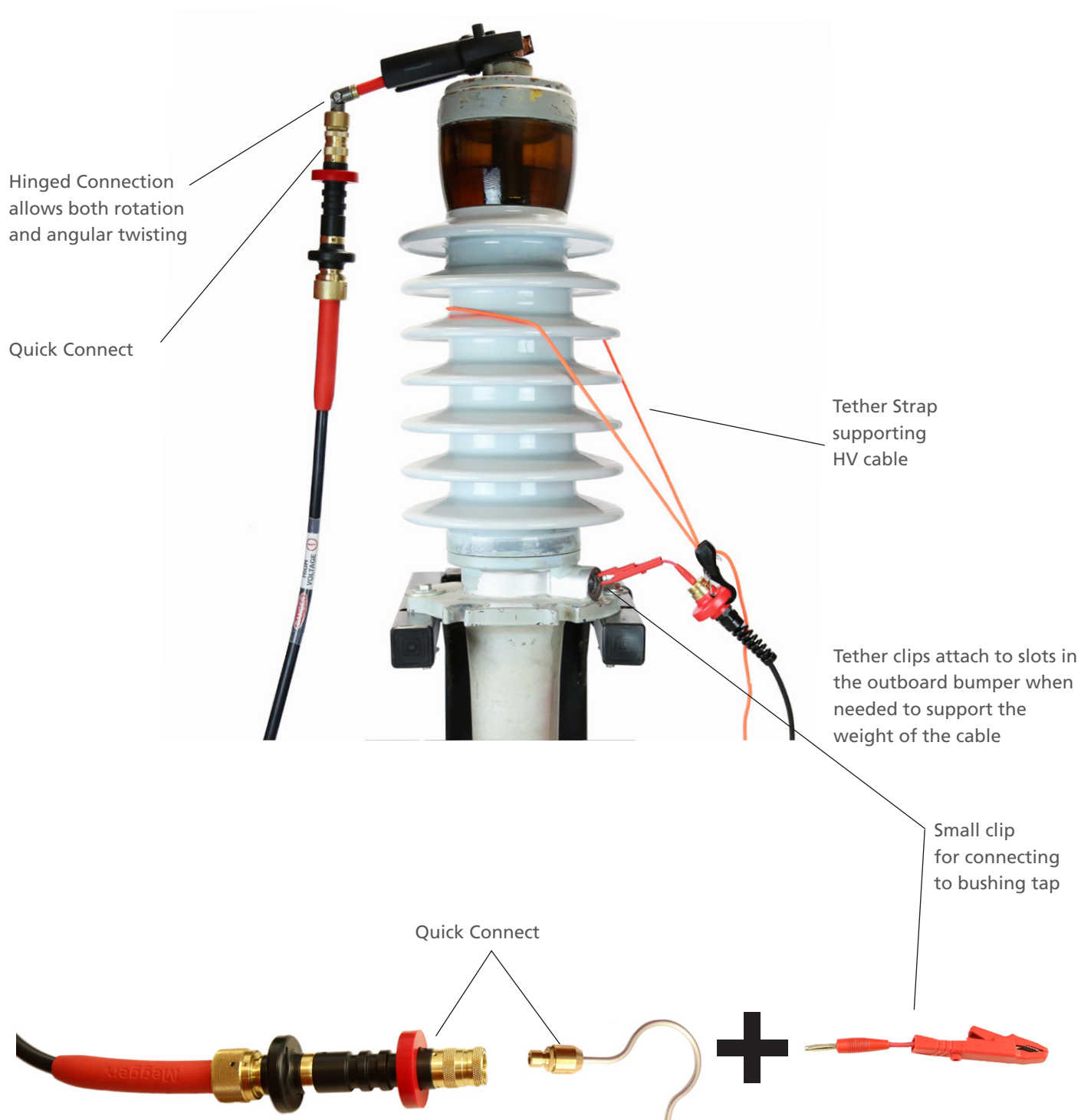


Optional Transit cart



## New High Voltage Cable for use with DELTA and TRAX series

Quality test connections improve the reliability of test results. Megger's new high voltage test cable addresses the challenges that are typically encountered when testing various assets to eliminate doubt from your testing conclusions.





# IDAX300/350

## Dielectric response and moisture analysis

- Automated measurement and analysis of moisture content, oil conductivity and tan delta/power factor
- Individual temperature correction (ITC) of tan delta/power factor and oil conductivity
- DFR measurements with AC test signals for reliable measurements in high - interference environments
- New multi-frequency technique performs a complete insulation assessment in 22 minutes



Megger is a leader in DFR testing with well over 20 years of experience performing DFR testing on different assets.

IDAX provides fast and accurate dielectric frequency response (DFR) measurements for insulation assessment including moisture content in the solid insulation, conductivity of the oil, power frequency tan delta and capacitance. Using true AC dielectric frequency response, IDAX gives reliable results even under high interference conditions and with the multi-frequency technique, it is also the fastest instrument on the market.

IDAX provides other test functions including excitation current, hot collar testing and DC insulation. The unique dielectric response of the insulation system can be converted into the thermal response of that specific component. In addition to power transformers, it is also suitable for use for bushings, current transformers, voltage transformers and virtually any other electrical component where tan delta and capacitance measurements are needed.



All IDAX models have three measurement input channels and can be equipped with two separate ammeters enabling two completely independent measurements at the same time, thus minimizing test time. The IDAX Software is capable to monitor dry-out process.

IDAX SPECIFICATIONS	
Output voltage (V peak)	0 to 10 V, 0 to 200 V, 0 to 2000 V (with VAX 020)
Output current	0 to 50 mA
Frequency range	DC to 10 kHz
Measurement channels	3, Red, Blue and Ground
Ammeters	1 (IDAX 300) or 2 (IDAX 300S and 350)
Max AC interference (50/60Hz)	1 mA @ 1:10 SNR,
Individual temperature correction	Tan delta/power factor to 20° C (0.1, 1, 10 Hz or line frequency) Oil conductivity to 25°C reference
Test time for moisture analysis	12 min, 2 mHz to 1 kHz, 30° to 45°C insulation temp
	22 min, 1 mHz to 1 kHz, 20° to 30°C insulation temp
	43 min, 0.5 mHz to 1 kHz, 10° to 20°C insulation temp
Instrument control	External PC (IDAX 300 and IDAX 300S)
Internal or external PC	IDAX 350
PHYSICAL	
Weight	
IDAX 300	4.9 kg (11 lbs), 9.9 kg (22 lbs) incl. flight case
IDAX 350	13.5 kg (29.8 lbs)
Accessories	8.5 kg (18 lbs) soft bag

# VAX020

## High voltage amplifier



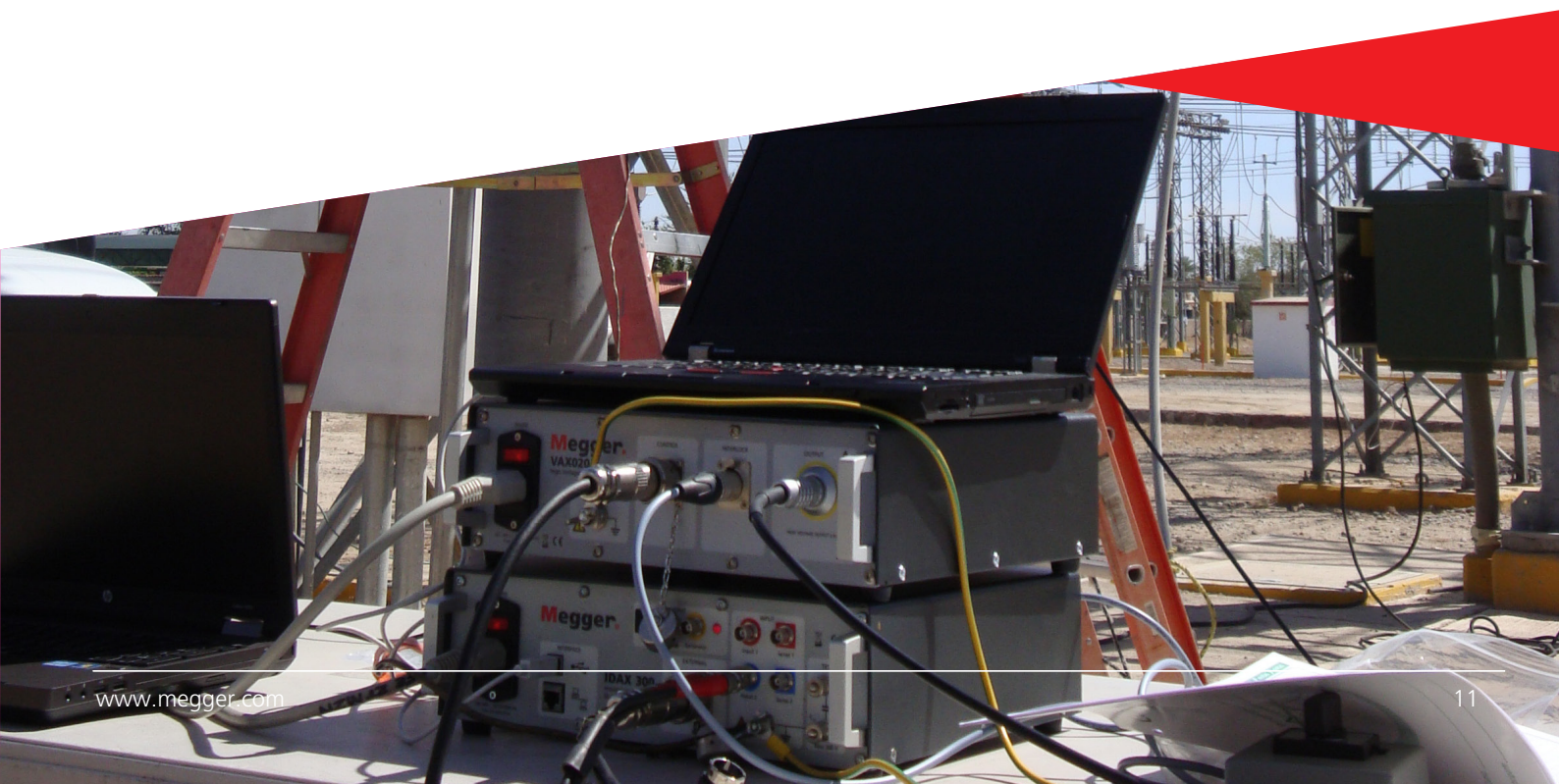
- High voltage amplifier enables IDAX measurements at 2 kV test voltage
- Large frequency range, DC to 1 kHz
- Compact design, weight only 4.4 kg

The testing capabilities of IDAX are extended with the addition of the high voltage amplifier VAX020. The voltage output increment from 200 V up to 2 kV (peak) is the most assertive solution to challenging DFR measurements in high interference environments (e. g. HVDC substations) or while measuring at very low frequencies on low capacitance objects (e.g. bushings and instrument transformers).

### VAX020 SPECIFICATIONS

Output voltage (V peak)	0 to 2000 V
Output current	0 to 50 mA
Frequency range	DC to 1 kHz
Max AC interference (50/60Hz)	10 mA @ 1:10 SNR
Max DC interference	20 $\mu$ A
PHYSICAL	
Weight	4.4 kg

VAX020 allows not only HV DFR measurements but also measurement of excitation current, capacitances up to 80 nF at 50 Hz (67 nF @ 60 Hz) and hot collar testing at 1.4 kV (RMS). IDAX together with VAX can also be used for DC insulation resistance measurement (including polarization index and dielectric absorption ratio) at 2 kV.





# CDAX

## High precision capacitance and dissipation factor test set

- High accuracy and wide measurement range
- Fast and automated measurement process with direct readings of results
- Measures capacitance, resistance and inductance in combination
- High accuracy ratio measurements with direct reading of measured ratio and phase deviation
- Optional LabView and C# interface



CDAX is a precision instrument that combines a bridge and direct (vector) capacitance and dissipation factor test set to be used with an external AC power source and a standard capacitor to form a complete measurement setup for capacitive, resistive and inductive loads.

CDAX 605 is designed for laboratory and production line testing of electrical equipment insulation and insulating materials as well as calibration of CCVTs and other precision ratio devices. Testing can be performed at almost any voltage level depending on the rating of the equipment, the power source and the capacitor.

The unit will accept a test current up to 5 A from the specimen under test which can be increased by using an external current transformer.

The input voltage to the device can be measured with a traditional reference capacitor while the secondary low voltage can be measured with a calibrated resistive divider such as the CRD 605 accessory. The advantage of two independent input channels is that it allows simultaneous measurement.

A CDAX test instrument replaces traditional bridges and has a unique fully automated test process eliminating time consuming manual balancing. The unit is ideal for use in a manufacturing environment where results are stored such as in Labview or C#.

CDAX SPECIFICATIONS	
Test voltage	Pending generator, standard capacitor and test object
Test frequency range	5 to 400 Hz
Reference and test current	15 $\mu$ A to 5 A
MEASUREMENT RANGE	Range limit is given by test current and voltage of used power source
Capacitance accuracy	0.02 %
Dissipation factor accuracy	0.05 % of reading + 0.002 %
Phase accuracy	0.02 mrad
Recorded values	Current, voltage, capacitance, inductance, resistance, tan delta, phase, ratio
PHYSICAL	
Weight	4.4 kg



## OTD

### Oil Tan Delta Testing



- Fully automated standard and user defined tests - Supports all international standards
- Integrated test cell heating and cooling systems
- Efficient oil fill and integrated automated oil drain facility
- IEC 60247 Innovative Test Cell - easy to assemble and clean
- Stores up to 50 records on-board and download to PC
- Compact and lightweight (22 kg / 48.5 lbs.)

The Oil Tan Delta (OTD) is a laboratory instrument, which measures the Tan Delta, Resistivity and Relative Permittivity of insulating liquids. These tests give a wider picture of the overall quality of the insulating oil, and will indicate if there is any contamination. Megger has developed features of the OTD to ensure that productivity levels within laboratories are maximised.

## KF875 and KF-LAB Mk II

### Karl Fischer Testing



- Coulometric Karl Fischer titrimetry
- KF875 optimized for insulating oil with an SG of 0.875, completely portable
- KF-LAB MkII offers greater flexibility, versatility and sample data input than the KF875; also completely portable
- KF-LAB MkII analyzes materials with an SG between 0.6 & 1.4, plus insulating oils with an SG of 0.875

Over 20 years experience has led to the development of the Megger KF875 and KF-LAB MkII Coulometric Karl Fischer Test Sets designed to determine moisture in oil, to provide highly accurate results on-site. The KF875 and KF-LAB MkII are highly portable instruments, complete with integral printer and carrying case, are easy to use and provide highly accurate results.



# OTS Series

## Oil testing dielectric breakdown

- Lightest portable unit, starts at 16 kg
- 9 cm colour display for outdoor on site use
- Battery or line powered
- Precision lockable electrode gap adjustment
- Automatic oil temperature measurement
- Direct output voltage or current breakdown detection

OTS range of oil test sets are fully configurable to comply with International standards including ASTM D877, ASTM D1816 and IEC 60156. The test sets perform accurate breakdown voltage tests on mineral, ester and silicone insulating liquids. Moulded test vessels give repeatable results in the field and laboratory, with lock-in precision electrode gap setting adjustments. The transparent, shielded lid is a key feature enabling users to observe the test chamber.

The OTS AF units are available in 0 to 60, 80 and 100 kV. These units are line powered and provide unique facilities for quick and easy replacement of test vessels. VCM 80 and 100 voltage meter accessories can be used for monitoring the output voltage.

The OTS PB units are small and lightweight to enable field testing. Available in 60 and 80 kV models, the units can be both line and battery powered.



Look on the Megger web site for our book on

“A guide to insulating oil dielectric breakdown testing”.

# TTRU3

## True 3 Phase Transformer Turns Ratiometer



The NEW Megger TTRU3 transformer turns ratiometer uses a revolutionary design to perform a complete series of measurements on a transformer, including 3Ø step up turns ratio testing (patent pending). 3Ø voltage output offers numerous advantages to testing with today's busy schedules.

Features include:

- Validation and recognition of phase relationship of vector groups facilitated with on screen vector rotation and automatic vector recognition
- Accurate measurement of phase shift relationship (for phase shifting transformers and Zig Zag vector configurations).
- Faster testing (10s) – all 3 phases tested simultaneously
- More reliable - removes the requirement for internal relay switching which is a common cause of failure

The TTRU3 is an important tool for determining the mechanical condition of transformers. All ratio tests are performed in one instrument, with only one 3Ø lead-set connection. The TTRU3 utilizes the latest 7 inch (180 mm) color touch display, as well as an optional printer so you never lose your results. This is complimented with remote control which can be operated from your PC, as well as the ability to download results to a USB memory device.

Learn more at **TTRU3.com**

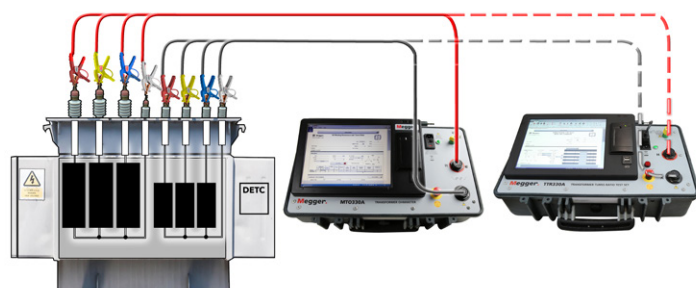
- Guaranteed accuracy  $\pm 0.05\%$  from  $-20^{\circ}\text{C}$  to  $+50^{\circ}\text{C}$
- 3Ø test voltage - up to 250V
- Phase shifting & zig-zag transformers tested easily and accurately
- Smallest/lightest 3Ø test set on the market
- Fast 3Ø tests - less than 10 seconds
- Patent pending 3Ø Step Up Testing
- Unique kelvin clamps with adjustable 3-inch jaw
- Banana plug input for connection to terminal blocks
- Turns ratio % error vs nameplate with pass/fail
- OLTC control





# MTO

## Winding Resistance Testing



- Simultaneous winding measurements
- OLTC make before break detection (MTO2XX and MTO3XX)
- Computer or manual control with internal memory
- Reading stability indicator

MTO series of instruments offer accurate and fast winding resistance test times using a single current source for four simultaneous measurements minimizing testing time.

For testing LV delta windings (>1000 A) where test times for each tap reach up to 15 minutes each, MTO250 offers a 50 A test current reducing testing time down to seconds.

The 3 phase leads set of our MTO 300 is fully interchangeable with TTR series Instruments, thereby minimizing testing

times when both measurements are used together.

- MTO106 – 6 A, Single-phase, 2 ch, manual
- MTO210 – 10 A, Single-phase, 2 ch, manual
- MTO250 – 50 A, Single-phase, 2 ch, manual or PC control
- MTO300/330 – 3-Phase/6-winding measurements, 10 A, with stand-alone industrial controller or remote control

MTO SPECIFICATIONS	
Output current - Max	6 A DC (MTO106) 10 A DC (MTO210 and 300) 50 A DC (MTO250)
Open-circuit voltage	MTO106: 48 V DC MTO210: 40 V DC MTO250: 50 V DC MTO300: 40 V DC
Resistance:	10 $\mu\Omega$ to 30000 $\Omega$ (MTO106) 10 $\mu\Omega$ to 2000 $\Omega$ (MTO210 and 300)
Accuracy:	MTO106: $\pm(0.25\% + 1 \text{ digit})$ MTO2XX and MTO3XX: $\pm(0.25\% \text{ reading}, \pm(0.25\% \text{ full range scale when current has stabilized})$
Resolution:	Readings: 4 digits Current: 6 digits



MTO250



MTO106

## 3-Phase Ratio and Winding Resistance Analyzer

- The solution for measuring ratio + winding resistance safer and quicker than traditional methods
- One control interface for both functions
- Combined Test Form
  - One can test either ratio or winding resistance, all controlled and viewed from a single form.
- One lead set
  - One connection to the transformer
  - Twice as safe, 50% lighter, easier transformer hook up and take down



The Megger MWA3xx Transformer Winding Analyzer is an advanced 3-phase transformer test system delivering portability, reduced set-up time, increased job-site safety, and effortless productivity. The MWA3xx provides complete ratio, phase and winding resistance measurements for a 3-phase transformer. All ratio and winding resistance tests are performed in one instrument, with only one 3-phase lead-set connection. The MWA3xx utilizes PowerDB as a single software platform saving the user additional time with only one set-up and one easy-to-read data report.

The MWA3xx is designed to test power, instrument, and distribution transformers in high noise, harsh outdoor environments or in an indoor manufacturing process. It is ideal for testing complex 3-phase transformers (with tap changers, bushing CTs, and tertiaries) in a fraction of the time taken with traditional test equipment.

- All transformer types and sizes – with and without OLTC tap changers
- Bus bar connections, circuit breakers contacts
- Testing includes:
  - Ratio
  - Polarity
  - Winding resistance
  - Demagnetization
  - Excitation current
  - Make/break transition & phase
  - Magnetic Balance
- Industrial controller with 300 mm (12 inch) sunlight redable touch display

### MWA SPECIFICATIONS

#### Ratio & Phase Measurements

Maximum turns ratio range	45,000
Turns ratio accuracy	0.10%
Test Voltages (V)	8/40/80
Max Current (mA)	500.0
Auto detect vector diagrams	✓

#### Winding Resistance Measurements

Output Current - Max	10 A DC
Open-circuit voltage	40 V DC
Resistance Accuracy (%)	±0.25 % reading, ±0.25 % range
Demagnetization	✓



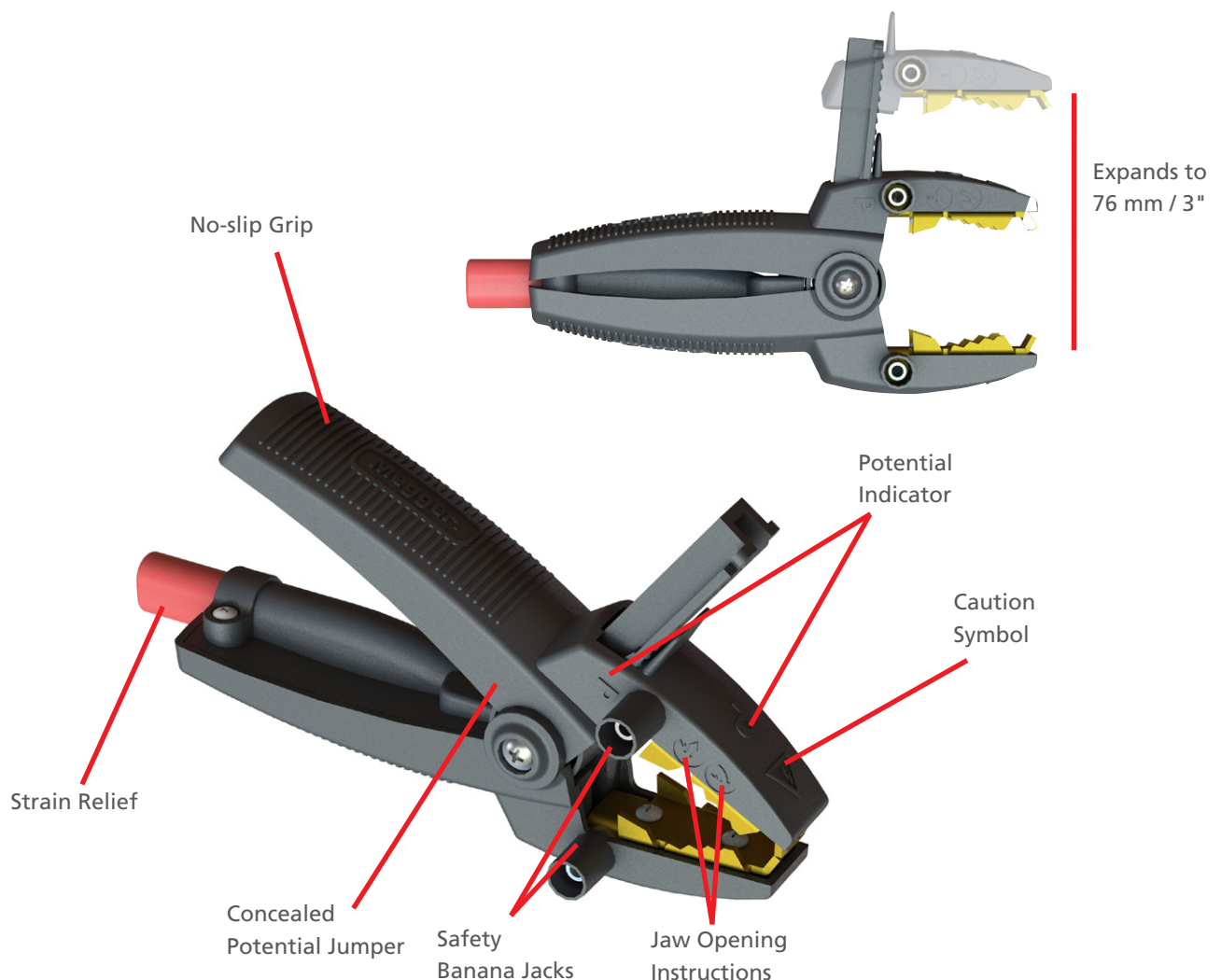
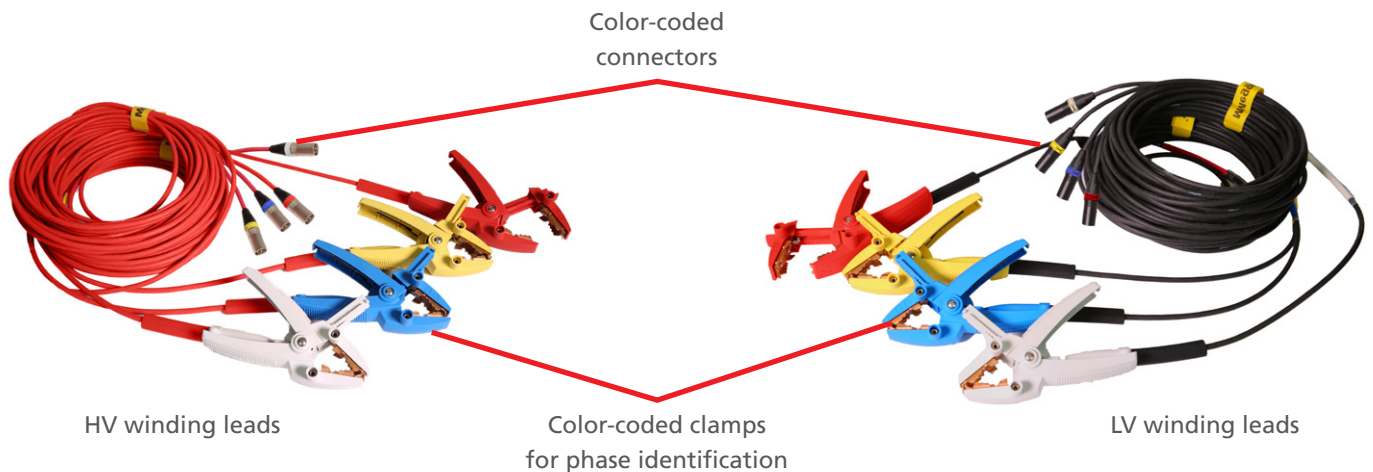
MWA Side panels



## UNIVERSAL LEAD SET for MTO, TTRU3, MWA and TRAX

The 3Ø Universal lead set simplifies connecting to any transformer. The durable kelvin clamps extend up to 76 mm / 3" for connecting to any bushing size. Lead spans range from 5m (15ft) to 30m (100ft), ensuring you can connect and test any transformer configuration. All of the leads can be connected in one ladder climb, reducing the risk of fall injuries, and color-coded lead jackets and clamps make it

easy to verify proper connections with your feet safely on the ground. The kelvin clamps also accept safety banana plugs, making it easy to connect the 3Ø lead set to a CT terminal block. Electrical shock and potential markings are clearly displayed on the clamp, informing operators how to connect safely and securely. The universal lead set can be used with TTRU3, MWAs, and most existing MTOs and TTRs.



## Sweep frequency response analyzer



- Complies with and exceeds international standards for sweep frequency measurements
- Smallest and most rugged sweep frequency analyzer on the market
- Advanced analysis and decision support built-in to the software.
- Ground Loop Detection feature to verify test ground setup (FRAX 101 and FRAX 150)
- Extensive file import-export capabilities including CIGRE and xml formats

The FRAX series of sweep frequency response analyzers is based on comparative analysis where a measurement is compared to a reference fingerprint.

The superposition of curves is a direct indication whether geometrical and/or electrical changes have taken place within the transformer.

The measurement is easy to perform capturing a unique fingerprint of the transformer. All FRAX models fulfill and exceed sweep frequency response specifications in international standards including IEC 60076-18, IEEE C57.149, CIGRE 342 and DL/T-911.

FRAX 99 is the base model; FRAX 101 allows for larger dynamic range measurements and wireless communication; and both units are operated from a PC. FRAX 150 has the same specifications as FRAX 101 but has an internal computer. FRAX 101 has a battery life of 8 hours.

A powerful software interface will guide the users step by step in the measurement process, minimizing testing time and ensuring accurate and repeatable measurements.

### FRAX SPECIFICATIONS

Output voltage	20 V (FRAX 99) 0.2-24 V (FRAX 101 and 150)
Measurement voltage	10 V @ 50 $\Omega$ (FRAX 99) 0.1-12 V @ 50 $\Omega$ (FRAX 101 and 150)
Frequency range	0.1 Hz – 25 MHz
Frequency sweep settings	Low to high or high to low, logarithmic or linear
Number of points	Default 1046, user selectable up to 32000
Dynamic range (IEC60076-18) (+ 10 dB to internal noise level)	> 150 dB (FRAX 101 and 150) > 130 dB (FRAX 99)
Accuracy	$\pm 0.1$ dB from +10 dB to -50 dB $\pm 0.5$ dB from +10 dB to -100 dB (FRAX 101 and 150) $\pm 1$ dB from +10 dB to -100 dB (FRAX 99)
Analysis	Magnitude Phase Impedance Admittance Inductance Resistance
User defined formulas to the list of analysis tools	Cross-correlation (CCF), as in DL/T911-2004 or customer defined





# MLR10

## Leakage Reactance Tester

- Measures the short circuit impedance of transformers
- Useful in detecting and diagnosing winding deformation
- Capable of performing measurements in single- or three-phase transformers
- Optional capacitor bank testing (without the need to disconnect terminals)

The Megger Leakage Reactor Tester MLR10 is used to measure leakage reactance and other associated parameters in high voltage power transformers. Leakage reactance, or more generally leakage impedance, is measured at the transformer primary winding while the secondary winding is shorted. Ideally, a transformer's primary and secondary windings should be 100% coupled by magnetic flux, but in real transformers there is always a small amount of leakage flux. Leakage inductance is a result of this leakage flux.

The amount of leakage flux a transformer has is partially dependent on the configuration of the windings. Since leakage reactance depends on leakage flux, measuring a transformer's leakage reactance can give an indication of the condition of the windings. Changes in the leakage flux, and therefore the leakage reactance, are generally caused by winding mechanical deformation. The mechanical deformation can occur during shipping, installation, or a high current event while the transformer is in operation. Such changes can be detected by comparing before and after leakage reactance measurement values.



Automatic display of the following parameters:

- Test current
- Test voltage
- Power factor
- Inductance
- Resistance
- Impedance
- Impedance (in %)
- Reactance
- Reactance (in %)
- Delta X (in %)
- Delta Z (in %)
- Capacitance (via optional capacitor test probe)

# Transformer test van

## Test van for maintenance and diagnostic testing of power transformers



A dedicated and fully integrated test van, complete with all relevant instruments, accessories, and test leads, for commissioning and periodic maintenance tests.

The heart of the system is a switch box that enables automated software-driven selection of HV and LV methods and test schemes. This allows most instruments to share common test lead connections saving time and making operation safer. Physical interface with the instruments themselves is no longer required. Upon completion of each measurement, results are automatically transferred into a consolidated report.

PowerDB software allows comparative measurements with nameplate and previous measurements for trending.

Routine and advanced diagnostic techniques in accordance with the IEC 60060-3, IEC 60076, IEEE Std. C57.152.00, GOST 11677-85 and CIGRE 445 standards can be performed.

### ■ Routine and advanced diagnostic tests using multifunction or single purpose instruments

- Insulation Resistance
- Winding resistance / Dynamic resistance on OLTC
- Capacitance and dissipation factor for windings and bushings
- Turns ratio, vector group verification, excitation current
- Short circuit impedance
- Sweep Frequency Response Analysis
- Moisture-in-cellulose assessment with DFR technique
- Extended capabilities with TRAX (CT&VT, circuit breaker applications)
- HiPot for applied voltage tests up to 100 kV AC 50 Hz and 70 kV DC
- Power losses at reduced voltage for no-load and short circuit conditions
- Portables: Oil breakdown test, Oil Tan Delta, IR camera
- Partial discharge detection and localisation

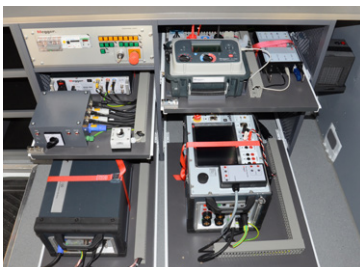
### ■ Centralized control and reporting

### ■ Two sets of cables (HV & LV) are shared among different instruments

### ■ Automated test circuit arrangement and switching process

### ■ Safe operation and user guidance through the tests

### ■ Easy extraction of mounted instruments for standalone use





# TRAX

## Multifunction test system for transformers and substations



The TRAX transformer and substation test system is designed to be a complete solution in transformer testing. TRAX is a multifunctional test system that replaces numerous individual testing instruments for complete assessment of transformers and their components. Testing with TRAX is a time saving and cost effective alternative to using separate instruments.

TRAX 280/279 is capable of providing an AC output of 800A and 2.2 kV, (2000 A and 12 kV with accessories) with an adjustable frequency range from 1 to 500 Hz. TRAX 220/219 can produce an upto 200 A AC output. These variable levels of voltage and current can be generated and measured with high precision, allowing TRAX to test for turns ratio, excitation current, winding and contact resistance, impedance, tan delta/power factor and various primary tests for LV, MV and HV electrical apparatus. The trouble-free design provides access to all outputs from the side panel of the TRAX.

- Power transformers
- Tap-changers (DETC and OLTC)
- Instrument transformers (CTs and VTs)
- Bushings
- Circuit-breakers
- Grounding systems
- Reactors

### TRAX software

It is the software that makes the TRAX a flexible and user friendly system. All systems are supplied with the basic software package; customers can then opt for additional packages which increase the versatility of the system by adding instrument apps.

**Advanced transformer** will add the ability to make dynamic OLTC measurements (true DRM), frequency response of stray losses (FRSL) and magnetic balance.

**Instrument transformer**, this package will enable ratio, burden, and polarity measurements for CTs and VTs. Other tests include CT winding resistance measurement and excitation curve.

**Substation**, this package adds circuit breaker analysis, primary injection timing.

**Line impedance**, together with specifically designed hardware, will add measurement of line impedance and calculation of k-factors for accurate distance relay configuration



TRAX Apps for various measurements/applications



The user interface allows full manual control where the user defines a specific test setup. Alternatively, a variety of individual instruments/apps are available to perform different tests like winding resistance, turns ratio, impedance measurements, circuit breaker analysis and more. The tests measurements can be organized and reported as separate tests or as a combined full set of test results for the same asset. TRAX can be used with an integrated touch screen or external computer device with a Chrome web browser.

- Winding resistance
- Demagnetization
- Load tap-changer (OLTC) continuity and true dynamic resistance
- Turns ratio
- Excitation current
- Short-circuit impedance (Leakage Reactance)
- FRSL (frequency response of stray losses)
- Ground / earth / impedance
- Optional switchbox for one-time 3-phase connection
- Magnetic balance
- CT testing
- VT testing
- Voltage withstand
- Circuit breaker
- Tan delta/ power factor and capacitance

## Tan delta and capacitance accessory for TRAX

### TDX 120

With the use of the TDX accessory, the TRAX becomes a fully automatic 12 kV tan delta or power factor test set for the condition assessment of electrical insulation in high voltage apparatus.



TDX120 accessory for tan delta/power factor and capacitance measurements

## 3-phase switch accessories for TRAX

### TSX 300 and TSX 303

TSX 300 offers manual switching of phase under test. Meanwhile the TSX 303 allows the operator to automatically test all windings and taps with a single climb and connection.



TSX303 accessory for automatic, hands-free switching of designated phase source and measure leads between each phase measurement

## 2000 A current accessory for TRAX

### TCX 200

When the high-current output of TRAX 220/219 (max 200 A) or TRAX 280/279 (max 800 A) is not sufficient, the optional accessory TCX offers currents up to 2000 A. Because it is small, the TCX unit can be placed close to the test object, thus reducing the need for long heavy current cables.

#### TRAX SPECIFICATIONS

Input Power	100-240 V $\pm$ 10 %, 50/60 Hz
Output Voltage	0 to 250 V AC 0 to 2200 V AC 0 to 12 kV AC (with TDX option) 0 to 300 V DC
Output Current	0 to 10 A AC 0 to 200 A AC (TRAX 220) 0 to 800 A AC (TRAX 280) 0 to 2000 A AC (with TCX option) 0 to 100 A DC
Frequency Range	5-500 Hz (1-500 Hz for insulation testing)
Output contacts	2, for tap-changer and circuit breaker operation
Measurement channels	Internal measurements on output generators and output contacts 4 x multi-purpose voltage/current measurement 2 x DC voltage for resistance measurements 1 x transducer input 3 x timing 1 x trig input
3-phase one-time connection	With TSX option
Tan delta and capacitance measurements	With TDX option
Weight	26 kg (TRAX 219/220) 29 kg (TRAX 279/280)

Learn more at  
[megger.com/TRAX](http://megger.com/TRAX)



# MRCT

## Current (CT) Transformer Testing



- Multi-tap simultaneous testing reduces test time by 5
- Smallest and lightest 2 kV secondary voltage injection unit on the market
- Accuracy to support testing of metering and protection class CTs
- Integrated insulation resistance, winding resistance and demagnetization testing
- Completely automated testing and test report with one touch operation
- Optional Integrated VT/CVT test system
- Optional integrated single phase relay test set, 60 A and 300 V AC/DC

The MRCT is the evolution of testing for current transformers (CT). This instrument provides the ability to perform the testing up to 5 times faster than with traditional instruments, and while testing, results are plotted, displayed and presented in a complete test report format.

The MRCT has also added insulation resistance test as well as demagnetization to its capability. This helps complete all the required testing as per IEC and ANSI standards without the need for additional test equipment or leads.

### Configuration options

- CT with option to add relay test
- Alternative DC Technique for testing CT knee point up to 40KV
- VT testing and CVT testing (optional)
- IEC 61850 GOOSE
- Bluetooth®
- Remote operation or on-board display

The MRCT's unparalleled noise immunity makes it capable of delivering dependable and accurate results even in extra high voltage substations.

#### MRCT SPECIFICATIONS

Saturation test	0 to 2000 V, 1 A maximum
Ratio measurement	0 to 20000
Winding resistance test	0 to 30 $\Omega$
Insulation test	500 V to 10 G $\Omega$ 1000 V to 20 G $\Omega$
Weight	16.7 kg (36.7 lb)

# MVCT

## Current Transformer (CT) and Voltage Transformer (VT) Testing



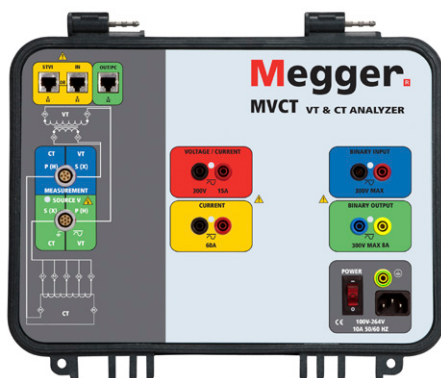
The Megger MVCT test set is a lightweight, robust, portable unit (less than 20 lb/10 Kg) capable of testing both current and voltage transformers with accuracy suitable for protection and metering class instrument transformers alike.

The MVCT can be controlled via its large, full color, high resolution, sunlight readable TFT LCD touch screen display, via a laptop utilizing PowerDB or with Megger's existing Smart Touch View Interface™(STVI).

### MVCT SPECIFICATIONS

Saturation test	0 to 300 V AC, 0 to 300 V DC kneepoints up to 30 kV using an innovative new DC technique
Ratio measurement	0 to 20000
Winding resistance test	0 to 30 $\Omega$
Insulation test	500 V to 10 G $\Omega$ 1000 V to 20 G $\Omega$
Weight	9.7 kg (20 lb)

- Ability to test both VT and CT
- Easy to use one-button automated test plans
- Industry leading test duration using patented simultaneous tap measurements
- Smallest and lightest unit on the market
- CT Kneepoints up to 40kV
- CT grouped testing includes Demagnetization, Knee Points, Ratios, Saturation Curves, Winding Resistances, Polarities and Phase Deviation (on all taps of multi-ratio CTs)
- VT testing including Demagnetization, Ratio, Winding Resistance, Polarity and Phase Deviation
- Performs Secondary Burden tests
- Integrated 1 kV DC insulation test system





**Power Diagnostix offers  
a wide range of partial  
discharge testing and  
monitoring systems  
for transformers**





# Partial discharge testing for Transformers

Partial discharge measurements on power and distribution transformers are a proven tool to identify and locate insulation defects within windings, pressboard, leads, bushings, tap changers, or other components. Besides providing the required equipment for factory acceptance testing (FAT), Power Diagnostix offers a wide range of instruments for onsite investigations and for continuous online monitoring. Such offline or online measurements in the field generally serve as an in-depth verification of an initial trigger by a PD monitoring system or suspicious dissolved gas analysis results and can provide essential information about ongoing deterioration of components of the active part and bushings, for instance. Currently, offline partial discharge testing in the field after commissioning of new units is an emerging trend and already proved to be very effective to detect assembling or processing deficiencies. In these days the permanent PD surveillance of transformers in the grid is a proven technology to prevent unforeseen outages or irreparable damage. Accurate monitoring of phase resolved PD patterns and alarm thresholds are the required indicators to monitor in order to avoid a breakdown or system failure. With the *ICMmonitor*, Power Diagnostix provide such compact, stand-alone, and remotely accessible continuous monitoring system for power transformers offering accurate alarm functionality with consequent pre-warning messages to prevent worst case scenarios.

## FACTORY AND SITE ACCEPTANCE TESTING



The multi-channel *ICMsystem* Generation 5 greatly simplifies the PD acceptance tests on large power transformers. With its true parallel PD acquisition of up to on ten channels, the overall testing period is substantially shortened by features such the automatic calibration cross coupling matrix. A typical package for advanced PD analysis consists of a multi-channel *ICMsystem* offering both narrow and wide band PD pattern acquisition according to IEC 60270. The instrument comes with an embedded spectrum analyzer for advanced PD analysis in frequency domain. Moreover, it is an excellent tool to use in case of noisy test environments. New in this 5th generation is the embedded digital storage oscilloscope (DSO) for time domain analysis of electrical and acoustic signals. The *ICMsystem* software further offers direct transmission of acoustic time domain measurements to the *ICMacoustic* PD location software, providing an accurate graphical and mathematical triangulation functionality to locate PD defects in the main tank with high precision.

The *ICMcompact* with SPEC option is a good compromise for routine factory PD testing of distribution class transformers and instrument transformers. Its user friendly interface enables non-PD experts to efficiently handle factory acceptance testing. The embedded 40kHz-10MHz spectrum analyzer and effective noise gating features are excellent tools to cope with noisy factory environments.

In addition to the noise suppression functions of the instruments, Power Diagnostix offers a wide range of high voltage filters for induced or applied voltage testing.

## TYPICAL PACKAGES

Set for power transformer acceptance testing:

- 1 x *ICMsystem* Generation 5
- 1 x Built-in TCP/IP interface
- 1 x GPIB interface
- 1 x Software *ICMsystem* Generation 5
- 1 x Impulse calibrator CAL1D or CAL1B
- 9 x Preamplifier RPA1 or RPA1L
- 8 x Quadrupole CIL4M/V0μ5/2μ0
- 3 x Quadrupole CIL5M/V4μ0
- 3x T100/100 high voltage filter

Set for distribution transformer acceptance testing:

- 1 x *ICMsystem* Generation 5 or *ICMcompact* (incl. MUX4)
- 1 x GPIB Interface (with *ICMsystem*)
- 1 x Software *ICMsystem* Generation 5/*ICMcompact*
- 1 x Impulse calibrator CAL1D
- 4 x Preamplifier RPA1 or RPA1L
- 3 x Coupling capacitor CC100B/V
- 3 x T30/xx or T50/xx high voltage filter

## PD MONITORING

Partial discharge monitoring has become increasingly important in the past few years. Besides other parameters such as dissolved gas analysis, temperatures, vibrations, or load conditions, etc., the PD trending information completes a full set of monitoring data of a power transformer in the field. A wide range of standard bushing adapters (BA) is available to connect the measurement system to the capacitive tap of condenser bushings. Even special designs are available on request. Additionally, the standard setup using the bushing test tap could be extended with UHF drain valve sensors or embedded antennas in flanges. A good alternative for continuous monitoring are periodical online PD measurements using an *ICMsystem* or *ICMmonitor* Portable. In such case, signal decoupling can be done by either temporary installed measuring impedances or a permanent setup with bushing adapters (BA) and bushing coupling units (BCU).



# Partial discharge testing for Transformers

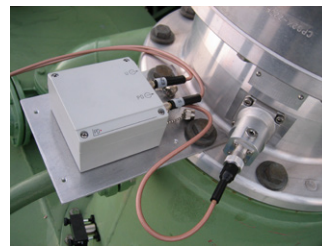
## Advanced Partial Discharge Detector

### ICMsystem Generation 5

The ICMsystem Generation 5 is part of the Power Diagnostix ICM series of digital partial discharge detectors. The ICMsystem is a powerful, versatile instrument for evaluating the condition of medium and high voltage insulation. The ICMsystem Generation 5 is usable over a range of frequencies of applied voltage, including power system frequency (50/60 Hz) and VLF (0.1 Hz).

The ICMsystem Generation 5 provides high-resolution digital PD patterns for classification of defects in high voltage insulation systems.

The multi-channel version of the ICMsystem is specifically designed to meet the requirements of partial discharge acceptance tests on large power transformers. The instrument builds on the acquisition core of the standard ICMsystem. However, by introducing an individual amplifier plug-in board for each channel, true parallel acquisition of the discharge magnitude of up to ten channels is achieved. The instrument can be equipped with optional features like RIV or acoustic PD measurement. Using the ICMsystem Generation 5 greatly simplifies partial discharge acceptance tests on large power transformers.



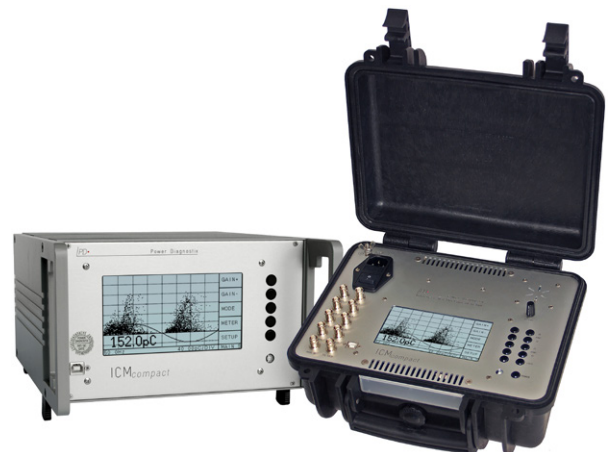
With the true parallel acquisition of the partial discharge activity on up to 10 channels, the overall testing period is substantially shortened. In acceptance test mode, the software shows up to 10 meter displays, each indicating PD level, voltage, and frequency of the specific channel.

## Digital Partial Discharge Detector

### ICMcompact

The ICMcompact is part of the ICM series of digital partial discharge detectors. The ICMcompact is a compact, stand-alone instrument for evaluating the condition of medium and high voltage insulation. It is often used in quality assurance and quality control tests in manufacturing of distribution class transformers. The easy portability, simple operation, and flexibility of the ICMcompact make it a good choice for routine PD testing in a variety of utility and industrial applications.

The optional built-in spectrum analyzer allows observing the frequency spectrum of a harshly disturbed PD signal and, hence, selecting frequency bands with fewer disturbances. Using this selected frequency for a PD acquisition gives a largely improved signal-to-noise ratio resulting in a clear pattern acquisition. The combination of spectrum analyzer and PD detector within one instrument opens a broad field of new possibilities when analyzing isolation defects even with large noise.



To adapt the basic ICMcompact unit to suit special measurement requirements, it can be equipped with various options, such as voltage measurement, which adds an oscilloscopic display showing the waveform of the high voltage and calculates  $\dot{U}$ ,  $\dot{U}/\sqrt{2}$ , Urms, etc., and a four- or twelve-channel multiplexer for cost-efficient acceptance testing on power transformers allows manual switching between 4 or 12 different PD sources.

# Partial discharge testing for Transformers

## Portable Partial Discharge Monitoring Device

### ICMmonitor Portable

The ICMmonitor Portable is part of the Power Diagnostix ICM series of digital partial discharge detectors. It is a compact, stand-alone instrument for evaluating the condition of medium and high voltage insulation. A built-in four- or eight-channel multiplexer offers scanning of three-phase systems or multiple sensors. It is used principally for continuous on-line monitoring of power transformers.

A series of standard bushing adapter and bushing coupling units is available to connect the instrument to the test tap of condenser bushings. This standard setup can be extended with UHF sensors for the oil drain valve or embedded antennas in flanges. Additionally, acoustic sensors can be used to locate a PD fault more precisely.

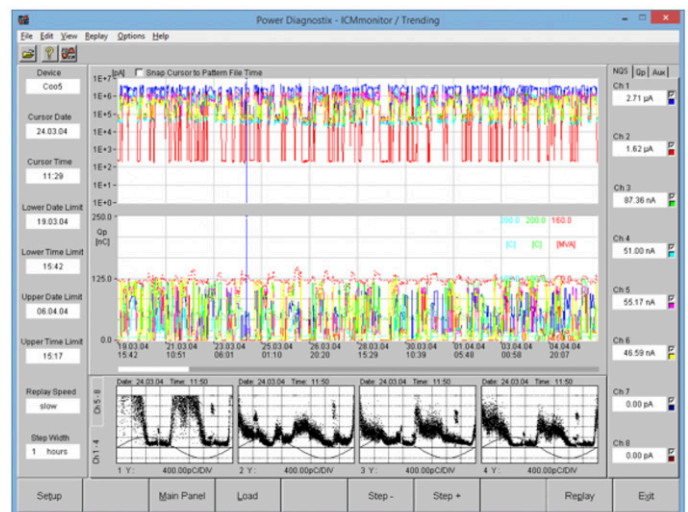
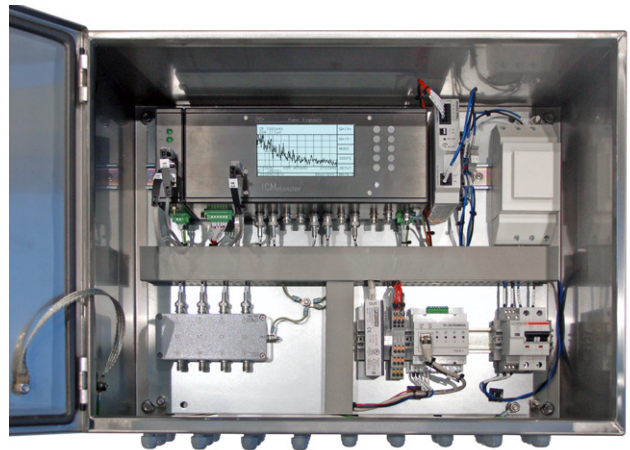
## Partial Discharge Monitoring System

### ICMmonitor

The ICMmonitor for permanent surveillance of power and distribution transformers is a monitoring system for fixed indoor or outdoor installation. The ICMmonitor has an easy-to-use push-button interface to navigate on-screen menus displayed on an embedded LCD panel. The LCD modes include a monochrome phase-resolved PD pattern display for classification of defects, a scope-like display showing charge pulses as a vertical line at the phase angle where they occur, a time trending display, and a monitoring display showing bar graphs of two key partial discharge quantities: The apparent charge value of the PD activity ( $Q_p$ ) and the absolute discharge current obtained by integrating the discharge values (NQS).

Users can set alarm levels of NQS or  $Q_p$  that will trigger when those values are exceeded. A triggered alarm will appear on the LCD, and activate an output relay on the ICMmonitor that can be used to drive a local alarm system. The ICMmonitor features various noise handling techniques. The noise gating module can be connected to an antenna or a current transformer to sense and remove noise without losing significant PD data. Another method available is simple windowing, that suppresses phase-stable pulses occurring in the defined windows.

With its built-in TCP/IP interface or an analog modem, the instrument can be controlled and observed remotely over a telephone or Internet connection anywhere in the world. Optionally, if a monitored system exceeds an alarm level set by the user, the ICMmonitor can place a call to a user-selected number.



Learn more at [pdix.com](http://pdix.com)



# Training

## Transformer life management (TLM) bulletins

Bulletins with must have information for each of a wide range of topics concerning the care and well being of transformers. You can subscribe the TLM bulletins from [www.megger.com/TLM](http://www.megger.com/TLM).

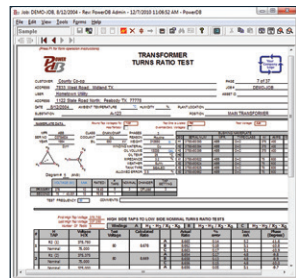
## Data management

### PowerDB

Power DB is a powerful data management software for acceptance and maintenance testing.

No database knowledge is needed with the integration of a powerful forms editor used to create or customize forms.

Includes equation calculations, temperature correction calculations, charting and much more.



## Product and Application Training

An additional benefit to purchasing any test instrument from Megger is the breadth and depth of the technical knowledge and experience that we can share with you. We have invested heavily in creating a local support network of engineers to provide a rapid response and who understand your application and needs.

Product and application training can also be offered on-site or at Megger facilities and it can be customized as per your needs. More information on course availability, upcoming webinars and other technical resources can be found on our website.



We can provide training on:

- **Fundamental Transformer theory**  
Practical exercises
- **Fundamental Transformer testing**
  - Electrical testing
  - Dielectric testing
  - Best Practices / Standards
- **Advanced Transformer Testing**
  - Sweep Frequency Response Analysis
  - Dielectric Frequency Response
  - Dynamic Resistance
  - Partial Discharge
  - Interpretation of advanced testing



# Get in touch

[megger.com/contact-us](https://megger.com/contact-us)



[twitter.com/meggeruk](https://twitter.com/meggeruk)



[youtube.com/meggerworld](https://youtube.com/meggerworld)



[facebook.com/meggeruk](https://facebook.com/meggeruk)



[linkedin.com/company/megger](https://linkedin.com/company/megger)





Megger Limited  
Archcliffe Road  
Dover CT17 9EN  
United Kingdom

[www.megger.com](http://www.megger.com)

TransformerCat2020\_EN\_V01

The word 'Megger' is a registered trademark. Copyright © 2020

**Megger**<sup>®</sup>

**G&E** ADVAN  
ENERGI