



# TMS 580

## Transformer Loss Measuring System



The measurement of the losses in power transformers is an indispensable quality-verification process. Due to the fact that normally the transformer user puts a penalty on the losses that occur in the load and no-load modes, the greatest possible accuracy in measuring the power losses is of primary economic importance. The TMS 580 system was specially developed for highly accurate measurements of power losses in transformers.

The TMS 580 system combines well-established and reliable hardware with up-to-date and powerful software. The system can be integrated into a computerized test field. The control computer can be connected to the factory LAN and therefore the measuring data can be externally accessed for backup and further processing.

The TMS 580 software supports two measurement modes. One mode is intended for conventional single or three phase transformers with up to six windings. In this mode the transformer can be completely defined with its power and voltage rating, frequency, tap changer, vector group, phase displacement, flux density, conductor material, core code and reference temperature.

For autotransformers or special purpose transformers, which cannot be specified with the standard attributes, the TMS 580 provides a flexible and free-definable measuring mode. Herein transformer losses are measured according to the DUT-specific configured setups.

The TMS 580 offers an exceptional operating convenience. The measuring procedures are software supported. Time can be saved because the precision high voltage transformer requires no manual range selection. The risk of using wrong voltage or current range is thus eliminated.

The TMS 580 has distinguished itself in the rugged environment of the transformer test facility. The design of the system ensures that its control and instrumentation function circuits remain unaffected by existing interfering fields.

### FEATURES

- Load loss measurement to reveal indications about stray losses and winding resistance.
- No-load loss measurement to determine transformer excitation.
- Heat run to verify temperature rises of oil and windings.
- Induced voltage test to check the voltage withstand capability of the insulations.
- Zero sequence measurement to identify phase sequence impedance.
- Wattmeter function to perform quick and easy measurements without any calculations.
- Self-check to calibrate all ranges of voltage and current channels.

### BENEFITS

**High measuring accuracy** of maximum  $\pm 0.35\%$  of the indicated power at a typical frequency of 50 Hz and a power factor of 0.05. The stability of the error is guaranteed for 12 month.

**Short throughput times** due to the elimination of instrument transformer rewiring, remote range selection and computer aided processing.

**Assured documentation quality** with a precise test report, which is generated automatically at the end of a measurement.

**Excellent technical services** are guaranteed by our skilled and experienced engineers. They ensure perfect operating condition over the systems entire service life.

**High operating convenience** reduces the learning process and minimizes faulty operations. Intuitive windows operating software helps getting familiar with the instrument very fast.

### APPLICATIONS

- Transformer Manufacturers
- Transmission Network Service Providers
- Distribution Network Service Providers
- Research Institutes

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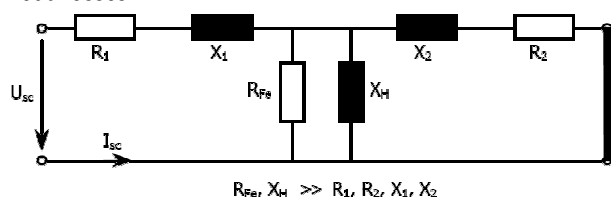
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## LOSS MEASUREMENT

The total losses of a transformer are the sum of the no-load and load losses. In general the actual loss figure has to be guaranteed by the manufacturer and are verified for the customer during the acceptance test. The appropriate standard is IEC 60076-8 clause 10 "Guide to the measurement of losses in power transformers".

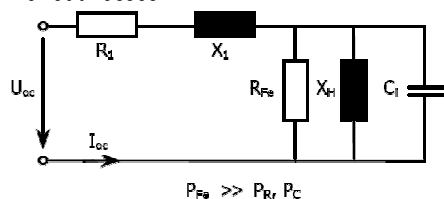
### Load losses



Exact knowledge of the load loss is important not only for capitalization of losses but also for the safe operation of large power transformers. The load loss represents the total losses developed within the transformer when rated current at rated frequency is applied to the transformer with the opposite winding shorted. It is made up of ohmic losses of the windings and internal connections, as well as the stray losses caused by leakage fields in the windings and the mechanical parts.

Load losses respectively short circuit impedance are also essential to know when the transformer will be operated in parallel with other transformers. Transformers in parallel service must have the same short circuit impedance otherwise there will be compensating currents between the parallel transformers which increase the total load losses and might cause damages.

### No-load losses



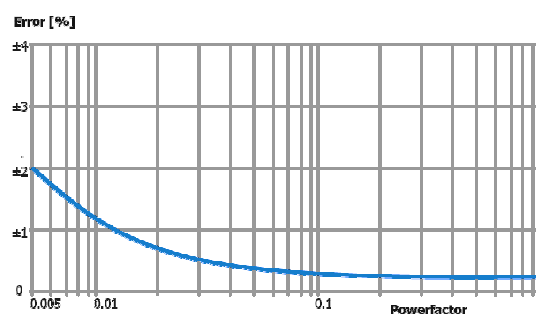
The no load losses of a transformer consists of core losses, winding losses and insulation losses. In general the dielectric and joule losses can be neglected, as they are several magnitude smaller than the iron losses. The measurement of the no load losses allows to detect defects in the core as for example core short circuits or saturation.

The current during a no-load measurement is inevitably distorted as a result of the non-linearity of the magnetizing curve. The voltage across the DUT is usually distorted because of the limited output of the test facility generators. While the current distortion is also present during in-service operation of the transformer, the voltage distortion must be recalculated to a sinusoidal waveform.

## MEASUREMENT ACCURACY

The power factor ( $\cos \phi$ ) of large transformers is small. This is why even minute phase angle errors of the instrument transformers can lead to substantial power measurement errors. The instrument transformers of the TMS 580 are specially designed to ensure very small phase angle errors, thus making additional error correction redundant.

The maximum power measurement error is a function of the power factor. The curve below shows the maximum error of the complete system as a function of the power factor in various ranges.



Measurement error of the integral system

To allow the current and voltage distortion to be properly measured the TMS 580 instrument accurately responds to the power frequency harmonic encountered.

The transformer measurement system TMS 580 includes a calibrator to verify the accuracy of the voltage channels, the current channel and the wattmeter (power analyzer). The test signals are injected directly into the voltage and current channels without any re-connections. With the "Self Test" procedure all measuring ranges are automatically checked at various power factors. The actual values are compared with the reference values that are logged and saved during the system calibration. A complete automatic test of all measuring ranges and phases, including report generation, is done in about 20 minutes. This test can also be done manually.

Together with the TMS 580 system the complete calibration certificate is issued, which attest the accuracy of the system prior to shipping. The calibration is performed according to NIST 1204 (National Institute of Standards and Technology, USA). The certificate contains the full results of all measurement performed.

A complete system calibration includes a reference calibration of the voltage and current transformers with certified, traceable precision instrument. This can be easily done on-site by our qualified service personnel.

## SYSTEM ARCHITECTURE

The transformer loss measuring system TMS 580 is designed for indoor use. As illustrated below the TMS 580 consists of four designated elements:

The **Voltage divider** is used to measure the phase to ground voltage with great accuracy. A metallic pressure tank with its corresponding internal concentric electrode forms the high voltage capacitance. The electrodes are insulated with SF<sub>6</sub>. The capacitor is practically corona free and is extremely stable. A guard electrode ensures that the proximity of other objects does not affect the capacitance. The low voltage section, which determines the ratio, is located in the TMS 581 voltage channel in the control cabinet.

The **Current transformer** consists of a toroidal coil in high pressure SF<sub>6</sub> insulation. A fibre reinforced plastic insulator, which is located between the aluminium head, and the base frame provides a flashover distance of more than half a meter. The accuracy over the entire range is attained with an electronic compensation circuit involving a zero flux transformer, located in the TMS 582 current channel in the control cabinet.

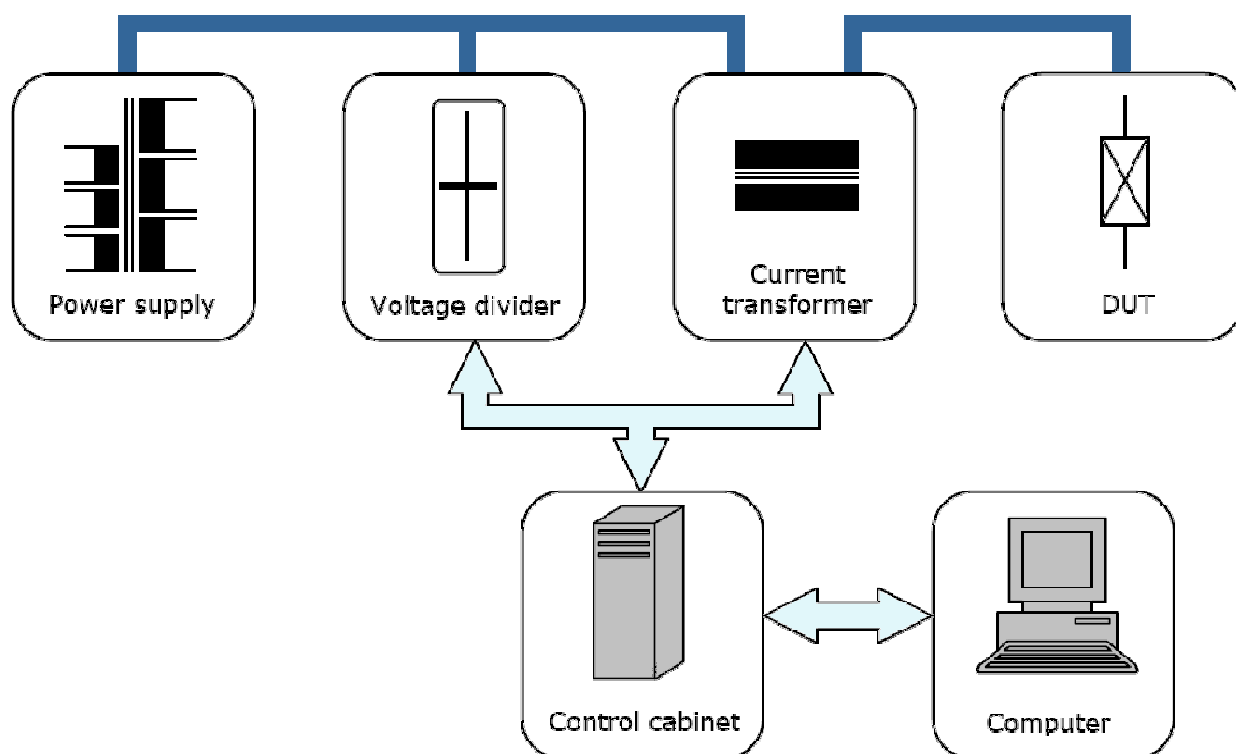
The measurement error is independent of the load. When the system is shut down or when the current transformer is disconnected or overloaded the secondary circuit is automatically shorted.

The **Control cabinet** contains the voltage and current channels, the wattmeter and the calibrator TMS 583. The voltage channel incorporates the low voltage capacitors of the HV divider. The current channel essentially contains the secondary current transformer and the flux compensation circuitry. Both, current and voltage channels can be controlled manually or by the TMS computer. The digital wattmeter simultaneously measures the voltages and currents. From these values the wattmeter computes the real power, the apparent power and the power factors. The calibrator makes it possible to easily check the accuracy of the voltage and current channels.

The built-in industrial **Computer** monitors and controls the full system. It runs an intuitive understandable Windows user interface software and is equipped with a colour TFT monitor, hard disk, floppy disk, a CD RW and laser printer.

All TMS 580 components are carefully tested prior and after final assembly to ensure accurate and reliable operation.

Haefely Test AG is fully ISO 9001 certified since 1992 and DIN EN ISO 9001:2000 (December 2000 edition) certified since June 2002.



## SOFTWARE

The powerful TMS 580 Windows operation software is a result of our close collaboration with transformer test system users worldwide. It has been improved over years with lots of customer feedback and inputs.

This software has been especially designed for intuitive, fast, easy and safe user interrogations. Status information and test results are visualized by graphical symbols, coloured values, pop-up windows and detailed graphs. Large buttons and standardized input fields ensure a correct and easy operation of the system.

An online-help function is available to get all supporting information on a mouse click.

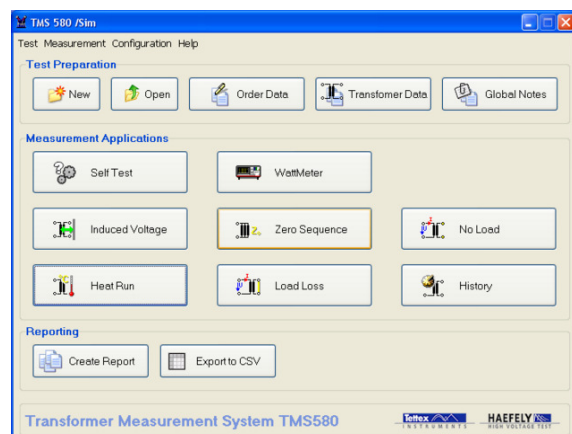
The TMS software can also be run in a simulation mode without the hardware connected e.g. for training purposes.

The main window of the TMS 580 software is divided into three sections:

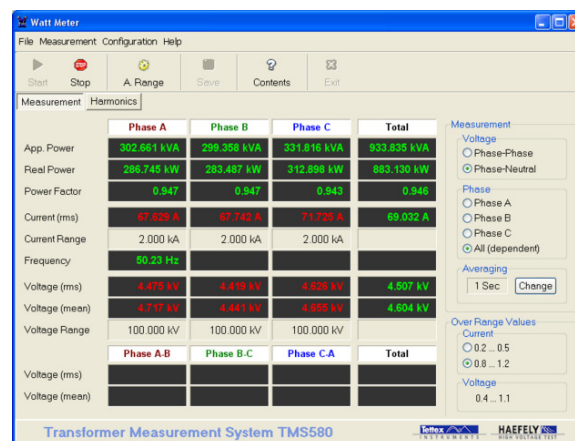
**Test preparation:** All file handling, setup and order data can be entered in this area. Additionally a continuous text field allows the input of general remarks like global documentation or application notes.

**Measurement applications:** This section provides access to the different transformer tests (load loss, no-load loss, heat run, zero sequence, induced voltage, wattmeter, self test).

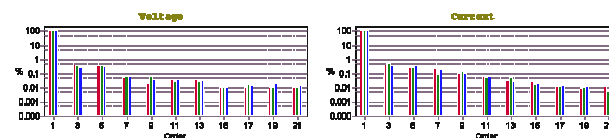
**Reporting:** This part of the window is for creation, viewing and printing of the test report. The report is stored in a XML/HTML format and can be exported into a comma separated value format (CSV) for further data processing (e.g. with Microsoft Excel).



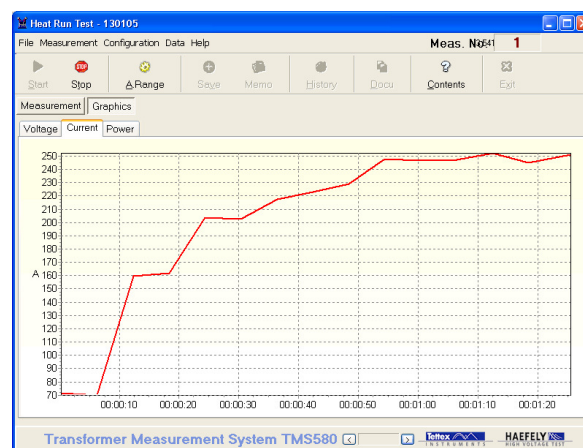
The measuring window of the TMS 580 software shows all data at a glance and can be operated by mouse. Green measurement values indicate correct measured data while red numbers mean a not optimal utilized or overloaded ranges. This supports easy status overview and ranging.



Beside the display of normal measuring values the TMS 580 software allows also harmonics to be measured and displayed. This is especially helpful when measuring no load losses to verify voltage and current distortions.



For heat run measurement the voltage, current and power can be graphically displayed. A first assessment is possible without any time-consuming data editing and analysing.



The TMS software contains a measurements history function with which all stored measurements can be accessed. Single measurements can be marked for reporting to create a user-defined report based on the stored data sets.

The TMS 580 software allows also measuring data import from resistance meter type 2291, 2292 and 2285.

## TECHNICAL SPECIFICATIONS

### Voltage Measurement

Model	Range	Accuracy*
TMS 580-100-...	100 V, 200 V, 500 V	0.12 %
	1 kV, 2 kV, 5 kV, 10 kV, 20 kV, 50 kV, 100 kV	0.10 %
TMS 580-200-...	100 V, 200 V, 500 V	0.12 %
	1 kV, 2 kV, 5 kV, 10 kV, 20 kV, 50 kV, 100 kV, 200 kV	0.10 %

\* at 40-110% range utilization, includes uncertainty of calibration

### Current Measurement

Model	Range	Accuracy*
TMS 580-...-2000	1 A, 2 A	0.15 %
	5 A, 10 A, 20 A, 50 A, 100 A, 200 A, 500 A, 1000 A, 2000 A	0.11 %
TMS 580-...-4000	2 A, 4 A, 10 A, 20 A, 40 A, 100 A, 200 A, 400 A, 1000 A, 2000 A, 4000 A	0.11 %

\* at 40-120% range utilization, includes uncertainty of calibration

### Power Measurement

Power Factor	Range	Accuracy*
cos $\varphi$ = 1.000	$\geq 1$ kV, < 20 A	0.20 %
	$\geq 1$ kV, $\geq 20$ A	0.17 %
cos $\varphi$ = 0.100	$\geq 1$ kV, < 20 A	0.25 %
	$\geq 1$ kV, $\geq 20$ A	0.19 %
cos $\varphi$ = 0.050	$\geq 1$ kV, < 20 A	0.35 %
	$\geq 1$ kV, $\geq 20$ A	0.26 %
cos $\varphi$ = 0.020	$\geq 1$ kV, < 20 A / 40A**	0.70 %
cos $\varphi$ = 0.010	$\geq 1$ kV, $\geq 20$ A / 40A**	1.05 %
cos $\varphi$ = 0.008	$\geq 1$ kV, $\geq 20$ A / 40A**	1.25 %

\* includes uncertainty of calibration / \*\* for 4000A System

### Safety Clearances

Model	to walls	between phases
TMS 580-100-...	0.5 m	1.0 m
TMS 580-200-...	1.0 m	2.0 m

### Environmental Conditions

Operating temperature	15 ... 30° C (desk and rack), 10 ... 40° C (HV components)
Storage temperature	-25 ... 55° C
Relative humidity	30 ... 80 % non condensing

### Power Supply

Voltage	115 V / 230 V    + 6 %, - 10 %
Frequency	50 Hz / 60 Hz
Power	600 VA (desk), 1200 VA (control cabinet)

### Weight and Dimension

Weight	2583 kg (gross), 1750 kg (net)
Shipping volume	6 packages, 12 m <sup>3</sup>

## ORDER INFORMATION

Name	Description	Ordering No.
TMS 580-100-2000	Transformer Loss Measuring System 100 kV / 2000 A	0265271
TMS 580-100-4000	Transformer Loss Measuring System 100 kV / 4000 A	0265281
TMS 580-200-2000	Transformer Loss Measuring System 200 kV / 2000 A	0265291
TMS 580-200-4000	Transformer Loss Measuring System 200 kV / 4000 A	0265301

### Scope of supply:

- 3 Voltage divider NK 100 or NK 200
- 3 Current transformers CT 2000 or CT 4000
- 1 Control cabinet with voltage and current channels, wattmeter and calibrator
- 1 Mini rack 12 HU with operator desk and integrated PCI 811 industrial computer.
- 1 Laser printer
- 1 17" TFT colour monitor
- 1 ASCII keyboard and mouse
- 1 Interconnection cables kit, length 60m (high-voltage / high-current connection cables are not included)
- 1 Instruction manual
- 1 Calibration report

## RELATED PRODUCTS



The **T2285** transformer measuring system, performs automated measurements of Turns ratio and Winding resistance. Heat run tests are supported by Cold resistance, Temperature measurement, Supervision during temperature rise, Cooling curve and Extrapolation.



The **TTR 2795** verifies transformer turns ratio, excitation current and the phase angle between primary and secondary windings.



The **MIDAS 2880** mobile insulation analyzer, measures capacitance, Dissipation Factor ( $\tan \delta$ ) and Power Factor ( $\cos \phi$ ) of HV insulations. A powerful 15kV high-voltage supply is built-in.



The **FRA 5310** sweep frequency response analyzer, records the transformer winding frequency response "fingerprints".



The **2291** and **2292** high current resistance meters are special designed for high performance measurement of high inductance, low value resistances such as transformer windings, etc.



The **RVM 5462** recovery voltage meter, records the recovery voltages and analysis the insulation condition by tracing their polarization spectrum.

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