HAEFELY HIGH VOLTAGE TEST

ACS/PSZ

AC Test Systems – Cylinder Type Transformers

USER BENEFITS

- Compact dimensions resulting in minimum space requirements
- High flexibility for connecting the HV lead
- Large range of application and low acoustic noise level (approx. 65 to 75 dBA)
- Sophisticated protection features for optimal test object & personnel protection

QUALITY

Haefely quality assurance complies with ISO 9001. The electronic measurement and control devices are designed and manufactured in-house. Our many years of experience in dealing with EMC is therefore an important asset.

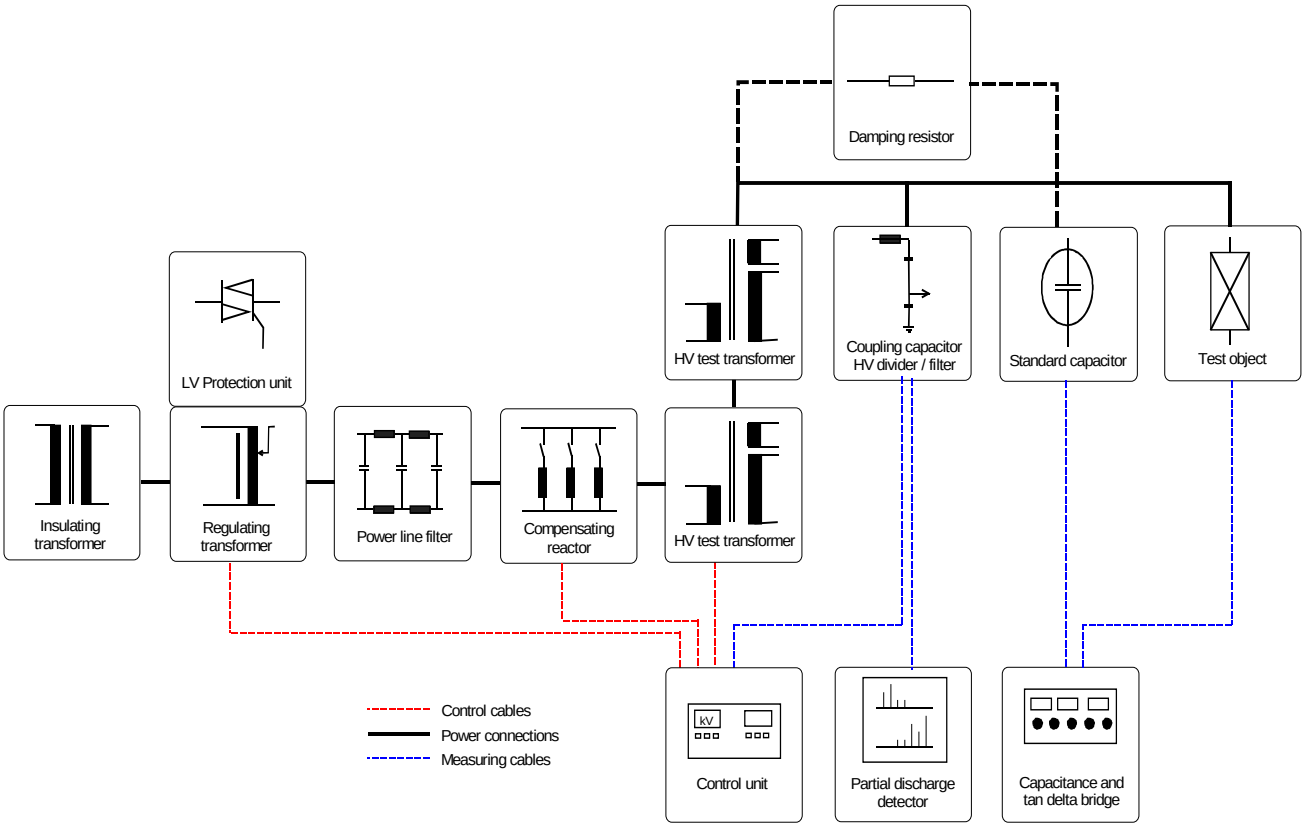
The design of the test system complies with the VDE 0104 standard for optimal protection of the operating personnel. The test system is shut-down in case of over-voltage, over-current and fast voltage transients. Damage at the fault area is minimised.

APPLICATIONS

Conventional AC test transformers are especially designed for testing objects of medium capacitance in the factory. These systems are particularly suited for tests requiring stable voltage even if the load changes during the testing (heavy corona, wet & pollution tests) or when the load is of inductive kind (inductive voltage transformers). The possibility to stack several of these transformers allows reaching very high voltages by keeping a reasonable floor space.

System with 300 kV test transformer and HV divider

BLOCK-DIAGRAM OF A TYPICAL TRANSFORMER CASCADE WITH 2 HV TEST TRANSFORMERS



SYSTEM CONFIGURATION

The test system includes following main components:

- Regulating transformer with shielded insulating transformer
- Power line filter
- Compensating reactor
- Low voltage protection unit (included in systems rated 600 kV or higher)
- Test transformer(s)
- Coupling capacitor / HV divider / HV filter
- Control system OT 276 (for ACS series) or OT 248 (for PSZ series)
- HV and grounding connections between HV elements. The connection to test object is usually not included.

AVAILABLE OPTIONS

- Air-cushion base frame for transformers
- HV filter inductance for coupling capacitor
- Damping resistance
- Standard capacitor
- Control system OT 257 instead of the OT 248, or OT 248 instead of the OT 276
- Additional HV connections
- Partial Discharge detectors
- Capacitance and power loss factor measuring bridges
- Other devices upon request.

FUNCTION OF THE TEST SYSTEM

The conventional cylinder type test transformers type PZ(T) steps-up the voltage coming from the regulating transformer type STL or STO. The controls act on the regulating transformer to adjust precisely the input voltage of the transformer and thus the test voltage.
A compensating reactor type KDL is connected between the regulating and the test transformers and compensates the capacitive power required for the test object.
This way, the regulating transformer and power line filter ratings can be kept small, and the requirements for the power supply are reduced.

The test transformers of type PZT and PZTL have an internal or external power compensation inductance to guarantee a linear voltage distribution among the transformer when these are stacked. This is of particular importance when 3 or more transformers are cascaded. These inductors also contribute to reduce the power required on the primary side (LV) of the test system.

Example of 1'500 kV, 1.2 A cascade made of 4 transformers

SYSTEM COMPONENTS SERIES ACS

AC test system Type ACS kV - A for 60' On, 1 x per day duty		Test transformer Type PZT(L) kV - A for 60' On, 1 x per day duty	Regulating transformer Type STL kVA for cont. duty	Coupling capacitor Type TK or KK(F) kV - nF
ACS 1000.10		1 x PZT 100-0.10	STL 10	TK or KK 100-1

AC test system Type ACS kV - A for 15' On, 60' Off, 6 x per day duty		Test transformer Type PZT(L) kV - A for 15' On, 60' Off, 6 x per day duty	Regulating transformer Type STL kVA for cont. duty	Coupling capacitor Type TK or KK(F) kV - nF
ACS 100-0.25		1 x PZTL 100-0.25	STL 12	TK or KK 100-1
ACS 100-0.70		1 x PZT 100-0.70	STL 25	TK or KK 100-1
ACS 200-0.25		2 x PZTL 100-0.25	STL 25	TK or KK 200-1
ACS 200-0.70		2 x PZT 100-0.70	STL 50	TK or KK 200-1
ACS 300-0.19		3 x PZTL 100-0.25	STL 25	TK or KK 300-1
ACS 300-0.25		4 x PZTL 100-0.25	STL 50	TK or KK 300-1
ACS 300-0.70		3 x PZT 100-0.70	STL 75	TK or KK 300-1

Other configuration or duty cycles are possible upon request!

SYSTEM COMPONENTS SERIES PSZ

AC test system Type PSZ kV - A for 15' On, 60' Off, 6 x per day duty		Test transformer Type PZT kV - A for 15' On, 60' Off, 6 x per day duty	Regulating transformer Type STL or STO kVA for cont. duty	Compensating reactor Type KDL kVA for cont. duty	Coupling capacitor Type TK or KK(F) kV - nF
PSZ 300-1.0		1 x PZ 300-1.0	STL 100	KDL 360	KK 300-1
PSZ 300-1.5		1 x PZ 300-1.5	STL 150	KDL 600	KK 300-1
PSZ 300-2.5		1 x PZ 300-2.5	STL 200	KDL 1'200	KK 300-1
PSZ 300-4.0		1 x PZ 300-4.0	STO 300	KDL 1'800	KK 300-1
PSZ 400-1.0		1 x PZ 400-1.0	STL 125	KDL 480	KK 400-1
PSZ 400-1.5		1 x PZ 400-1.5	STL 150	KDL 900	KK 400-1
PSZ 400-2.5		1 x PZ 400-2.5	STO 300	KDL 1200	KK 400-1
PSZ 400-4.0		1 x PZ 400-4.0	STO 500	KDL 1'800	KK 400-1
PSZ 600-1.0		2 x PZT 300-1.0	depending on system design		KK 600-1
PSZ 600-2.75		2 x PZT 300-4.0	depending on system design		KK 600-1
PSZ 800-1.0		2 x PZT 400-1.0	depending on system design		KK 800-1
PSZ 800-2.75		2 x PZT 400-4.0	depending on system design		KK 800-1

Other configuration or duty cycles are possible upon request!

AMBIENT CONDITIONS FOR THE AC TEST EQUIPMENT

Height above sea level	≤ 1000 m
for each add. 100 m, the HV rating must be decreased by	1 %
Relative humidity in main hall under non condensing conditions	≤ 90 %

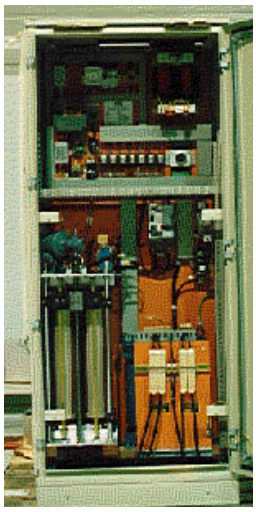
- Temperature averaged over 24 h for H.V. components — min. 0 °C, max.+ 30 °C
- Extreme temperatures for H.V. components — min.- 5 °C, max. + 40 °C
- Temperature for electronic controls (equipment to operate with the specified measuring errors) — min. +15 °C, max. + 25°C

DESCRIPTION OF THE TEST SYSTEM COMPONENTS

REGULATING TRANSFORMER TYPE ST(L)

DESCRIPTION

The regulating transformer adjust the input voltage of the test transformer practically without steps. The unit is for indoor operation. The driving motor allows a slow and a fast regulating speed (40-240 s from 0-100 % of the voltage). The zero start interlock forces the operator to start always from zero. The primary breaker and secondary contactor are placed in the regulator cabinet.
The power line filter can be built-in or attached to the regulating transformer cubicle. The galvanic separation is given by a separate insulating transformer.



Regulating transformer type STL 100

TECHNICAL DATA OF THE REGULATING TRANSFORMER SERIES STL (SOME RATINGS ONLY)

Type STL	Rated power cont. duty kVA	Secon-dary voltage V	Dimensions L x W x H approx. m	Weight net, approx. kg
STL 10	10	0 - 400	1.2 x 0.5 x 1.8	350
STL 12	12	0 - 400	1.2 x 0.5 x 1.8	350
STL 25	25	0 - 400	1.2 x 0.5 x 1.8	380
STL 50	50	0 - 400	1.6 x 0.6 x 2.0	570
STL 75	75	0 - 400	1.4 x 0.9 x 1.5	790
STL 100	100	0 - 400	1.7 x 0.9 x 1.5	990
STL 150	150	0 - 1000	1.0 x 1.8 x 1.5	1540
STL 200	200	0 - 1000	1.2 x 2.0 x 1.7	1700

TECHNICAL DATA OF THE REGULATING TRANSFORMER SERIES STO

Type STO	Rated power cont. duty kVA	Secon-dary voltage V	Dimensions L x W x H approx. m	Weight net, approx. kg
STO 300	300	0 - 1000	1.6 x 1.4 x 2.9	5000
STO 500	500	0 - 1000	1.7 x 1.6 x 3.0	6400
STO 800	800	0 - 1000	1.8 x 1.7 x 3.2	8600

POWER LINE FILTERS TYPE NLFA

DESCRIPTION

For the reduction of line carried noise from the mains.
The power line filter filters both phases and is connected to ground. The filter is built into the cubicle of air insulated regulating transformers or attached to their tank. Special arrangements are possible for big systems depending of local installation conditions.

Their power rating is adapted to regulating transformer rated power.

Typical insertion loss per phase measured at 50 Ω / 50 Ω, MIL-STD 220 A >80dB

in the following frequency range of 14 kHz...10MHz

COMPENSATING REACTOR TYPE KDL

DESCRIPTION

For the compensation of the reactive power of capacitive test objects.
The air insulated compensating reactor is connected between the regulating transformer and the test transformer. Therefore, the power rating of the regulating transformer and of a possibly pre-connected power filter can be kept small.
The compensating reactor comprises usually 3 inductors which can be combined to achieve up to 7 different power combinations. The re-connection is basically done manually. Upon request (option), a remote re-connection with switches actuated from the controls can be offered.

Compensating reactor type KDL 180

TECHNICAL DATA OF THE KDL COMPENSATING REACTOR SERIES

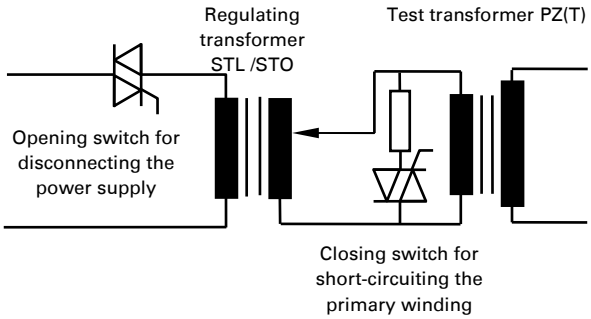
Type KDL	Rated power cont. duty kVA	Rated voltage V	Dimensions L x W x H approx. m	Weight net, approx. kg
KDL 180	180	400	1.1 x 1.2 x 1.0	550
KDL 360	360	400	1.2 x 1.2 x 1.0	850
KDL 900	900	1'000	1.6 x 1.3 x 1.4	1'800
KDL 1800	1'800	1'000	2.5 x 1.3 x 1.5	3'200
KDL 2800	2'800	1'000	2.7 x 1.4 x 1.5	4'200

As the compensating reactors are designed specifically to the system specification, only a few examples are given in the above table.

LOW VOLTAGE PROTECTION DEVICE TYPE NSP

DESCRIPTION

Used to prevent inadmissible high recovery over-voltages on the test transformer in case of disruptive discharges on the test object. The low voltage protection device NSP acts by opening the power supply and by short-circuiting the test transformer within a few hundred microseconds. This avoids repetitive flash-overs in the test object.



AC TEST TRANSFORMER TYPE PZ(T)(L)

DESCRIPTION

Test transformers are used for the generation of high AC voltages, and are part of a complete test system. The PZ(T) type test transformers are of the so-called insulating shell design. The merits of this design are:

- Small dimensions and reduced floor space requirements in the test laboratory
- Cascade connections by superimposing two, three or four transformer units, without an additional requirement in floor space (PZT transformers only).

General design

The test transformer are of the insulating shell design with metallic cover and base. The insulating cylinder is made of reinforced Fibreglass, covered with a moisture-rejecting paint. The PZT transformers have a tertiary winding. The test transformers are not completely filled with oil. The remaining air volume allows an oil expansion according to its temperature.
The windings are of layer-wound design with a high capacitive coupling between layers and turns. This design provides a high transient voltage withstand capability in case of external breakdowns.

Primary winding

The primary winding is divided into two groups. When the two winding groups are connected in parallel and the regulating transformer is set to 100 % voltage, the transformer reaches its nominal voltage. When the two winding groups are connected in series, only 50 % of rated voltage are attained with the same regulating transformer setting. This allows to test at low voltages with higher precision.

Dielectric

The dielectric materials consist of paper, transformer board and transformer oil. The insulating oil is Shell oil Diala D.

Test transformer cascade rated 200 kV; 0.7 A

Air dehumidifier

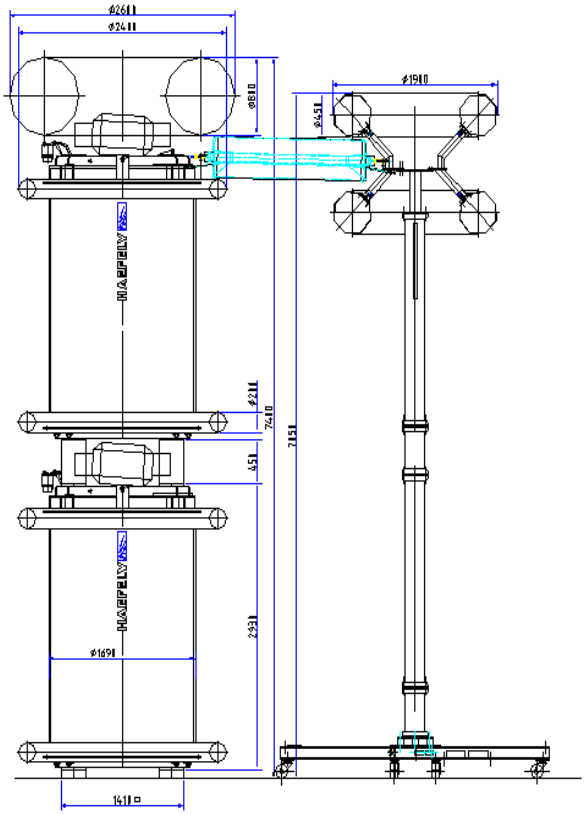
The cover of the transformer houses an Orange-gel breather to prevent the ingress of moisture.

Coupling (tertiary) winding.

The transformers for cascade operation type PZT & PZTL have a coupling winding rated in accordance with the cascade data.

Over-voltage protection

Surge arrestors are installed on the primary winding connections and to ground, to protect the transformer against over-voltages in the case of flashovers.



Layout of a test transformer cascade 800 kV, 2,5 A

Compensation. Only PZT transformers

To compensate the capacitive load, an iron-cored compensating reactor with air gaps is connected in parallel with the coupling winding of the test transformer. The compensating reactor allows a reduction in the input power and, in the case of cascade circuits, a uniform voltage distribution in the individual windings. This reactor is placed on the transformer upper cover.

Cooling

The transformers with high output currents or high duty cycles house an upper cooling-cover. The cooling equipment consists of a tank with cooling ribs. The insulating oil is conducted trough this tank by natural convection.

Top electrode

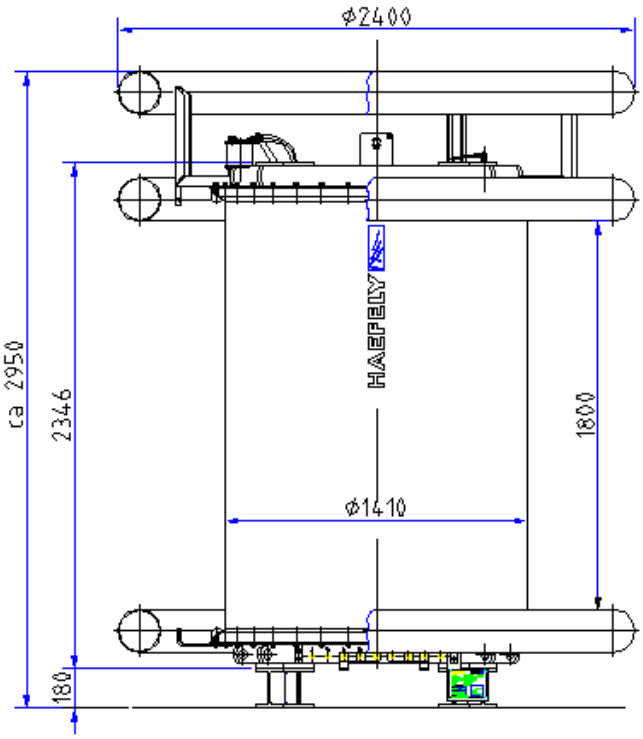
Depending of the transformer rated voltage, a top electrode is placed on its upper cover. The top electrode is either an aluminium toroid or a Polycon electrode.

Base frame

Normally the test transformer is placed directly on the floor. Upon request, the base frame can be equipped with air-cushions.

Interconnection of several test transformers

Individual test transformers can be connected both in series (cascade) for an increase of the output voltage, and in parallel for an increase of the output current. Moreover, three-phase configuration can be set up.



Layout of test transformer 300 kV, 1 A

200 kV cascade with 2 PZT 100-0.1 transformers

300 kV cascade with 4 PZTL 100-0.25 transformers

DIMENSIONS AND WEIGHTS

Some examples only

Transformer type PZ(T)(L)	Voltage Un kV	Diameter m	Height m	Weight of oil approx. kg	Total weight net, approx. kg
PZT 100-0.10	100	0.66	0.73	85	290
PZTL 100-0.25	100	0.85	0.70	110	385
PZT 100-0.70	100	1.30	1.20	440	1440
PZ 300-1.0	300	2.40	3.00	2'100	5'000
PZ 300-1.5	300	2.40	3.00	2'700	7'600
PZ 300-2.5	300	2.50	3.50	3'200	8'200
PZ 300-4.0	300	2.50	3.50	3'200	8'200
PZ 400-1.0	400	2.40	3.30	2'800	5'500
PZ 400-1.5	400	2.40	3.40	3'600	9'500
PZ 400-2.5	400	2.50	3.50	5'500	13'000
PZ 400-4.0	400	2.50	3.50	5'500	13'000
PZ 500-1.0	500	2.40	3.60	6'000	12'000

Other voltages, current or duty cycles are possible upon request!

VOLTAGE DIVIDER / COUPLING CAPACITOR / HV FILTER

DESCRIPTION

The coupling capacitors of the series KK or TK (and 9230) consist of 1 or more modular units, built into glass-fibre reinforced epoxy tubes. Their applications are:

- Partial discharge measurements with an optional coupling quadripole.
- Measuring AC voltages in the industrial frequency range.
- Attenuating interferences coming from the HV side (together with a HV inductance, KK only)

The standard base frame is fitted with castors for mobility. The capacitors are built for indoor use.

TECHNICAL DATA OF KK SERIES

Type KK	Voltage kV	Capacity nF	PD Level at Un pC	Type	Height H mm	Diameter top electrode D mm	Base frame dimension B mm	Weight net, approx. kg
100-1	100	1	≤ 1	B	720	300	350	15
200-1	200	1	≤ 1	B	1640	350	850	60
300-1	300	1	≤ 1	B	2600	660	1500	150
400-1	400	1	≤ 2	B	3300	1580	1500	270
600-1	600	1	≤ 3	C	4600	1900	2100	490
800-0.5	800	0.5	≤ 5	C	6000	1900	3100	650
800-1	800	1	≤ 5	C	6000	1900	3100	650

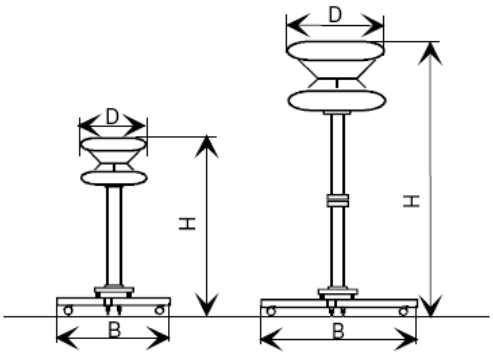


Fig. B Fig. C

Special HV filter inductance configuration

HIGH VOLTAGE FILTER FOR KK SERIES (OPTION)

By adding an inductance to the coupling capacitor, they form the high voltage filter KKF, which attenuates interference coming from the high voltage reactor / transformer side.
The high voltage filter inductance is connected between the transformer and the coupling capacitor and is usually placed in the top electrode.

Following inductance is available:

Type	Inductivity mH	Max. current A	Weight kg	Capacity of KK nF
F 600-2	600	2	3	< 1

Typical insertion loss (50 Ω / 50 Ω) at 40 kHz - 400 kHz ≥20dB

DAMPING RESISTOR

DESCRIPTION

The damping resistors consist of 1 or more modular units, built into glass fibre reinforced epoxy tubes. Their applications are:

- protecting the high voltage AC test transformer from transients when a flash-over occurs.

They are built for indoor use and connected between the test transformer (cascade) and the voltage divider electrodes. Their resistance is in the range of 1 kOhm.

Typical damping resistor arrangement on a 300 kV system

CONTROLS TYPE OT 276

DESCRIPTION

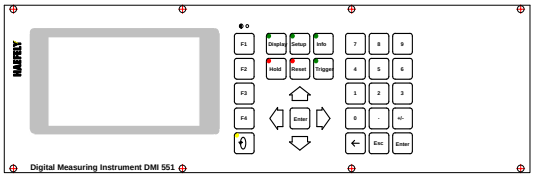
The controls OT 276 provides a safe and easy operation of transformer-type AC high voltage test systems. The unit is built into a standard 19" desktop housing. It has a high electromagnetic compatibility and does not need additional screening. It is based on relay technique.
We recommend using a separate digital measuring instrument like the DMI 551 AC for the voltage measurement.
As an option, the more sophisticated OT 248 or OT 257 can be offered.

Controls type OT 276

DIGITAL MEASURING INSTRUMENT TYPE DMI 551

DESCRIPTION

Used in conjunction with the OT 276 controls, the DMI 551 is a multi purpose measuring instrument for all kind of voltages present in high voltage test laboratories. It is built into a 19" standard housing, 3 units in height.



Digital measuring instrument type DMI 551

TECHNICAL DATA

Technical data are listed for a DMI equipped with all measuring channels; however they apply only for those the DMI has been ordered with.

AC VOLTAGE MEASURING CHANNEL

■ Measured values	Peak / √2 (capacitor), RMS (fast A/D conversion)
■ Display	kV, 4 Digits
■ Accuracy	±0,5 %, ±3 Counts
■ Input voltage	max 150 V RMS
■ Measuring range	5...100 %
■ Range setting	automatic
■ Input impedance	1 MΩ, 60 pF
■ Frequency of the measured voltage	40...400 Hz, +/- 0.5 % Accuracy
■ 16 2/3...40 Hz,	+/- 1 % Accuracy
■ Flash detection	polarity and last Peak / √2

CONTROLS TYPE OT 248

DESCRIPTION

The Operating Terminal OT 248 provides a safe and easy computer aided operation of transformer-type AC high voltage test systems. The unit is built into a standard 19" desktop housing. It has a high electro-magnetic compatibility and does not need additional screening. Due to the built-in safety interlocks the operator can fully concentrate on the test object. As an alternative, the more sophisticated OT 257 can be offered.

Controls type OT 248

All set or measured data are displayed on a bright 6.5" colour LCD display. An easy-to-understand graphical user interface is used for all information exchange.
Short key buttons perform the control of the AC test system with direct access to the main functions and scrolling menus handle the secondary functions easily.

At any time - in addition to the output high voltage output status - additional system information blocks can be visualized on the display:

- Over-voltage and over-current protection status
- Tuning and actual gap distance of the HV reactor
- System timer
- Output voltage and current of the regulating transformer

HIGH VOLTAGE MEASUREMENT

A front installed USB socket enables the connection of an USB-stick for the transfer of CSV data files on another PC into an Excel spread sheet. Data files can also be accessed via LAN.

The High Voltage measuring signal is derived from the built-in HV divider of the test system. The value of the high voltage is permanently displayed, either as peak /√2 or as RMS value.

In case of flashover at the test object the control unit automatically stores the last voltage measurement as well as the polarity of the high voltage during the discharge.

FEATURES

- Switch-on, switch-off of the primary circuit breaker and the high voltage contactor
- Manual variation of the output high voltage with two speed levels.
- Automatic raise of the output high voltage to a final value with a defined speed.
- Timer for switching off the high voltage automatically after a pre-set time period
- Remote control compensation reactors of transformer test systems
- Automatic control the resonance condition of resonant test systems
- Remote control DC test systems

TECHNICAL SERVICES

DESCRIPTION

Haefely Test AG has a dedicated Technical Services dept. with an experienced team of engineers doing the internal tests as well as the commissioning on-site and final testing of the test installations. The Technical Services dept. does also preventive maintenance, repairs and calibrations if required. This responsive team allows to minimise eventual down-times and assures the shortest possible reaction time should any question arise.

The full coverage of the warranty is granted only if Haefely Test AG has carried out the Technical Services. The charges for the delegation of our personnel are based on the terms and conditions of the Swiss Association of Machinery Manufacturers.

INSTALLATION

Large installations require experienced team of mechanical erectors for supervising the assembly the test systems.

SYSTEM AND ACCEPTANCE TESTS ON SITE

Once the system is erected, specialist engineers carry out the systems tests at the customers' site. The system test shall prove that the system works according to the specification at customer's site. The engineers give a first training to the operating staff.
These tests can also be done with a real test object under the responsibility of the customer.

TRAINING OF OPERATING PERSONNEL

The training is carried out by the Haefely senior engineer immediately after the systems tests. Detailed explanations about the use of the system, controls and measuring instruments are given, in addition to the operating manuals.

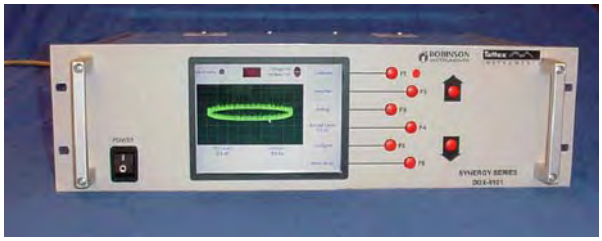
PREVENTIVE MAINTENANCE & SERVICE VISITS

Haefely Test AG can offer a regular service & maintenance visit on-site for checking the system condition & proposing necessary works. This is particularly useful for production line equipment.
This visit can also be combined with the system re-calibration.

ACCESSORIES

MEASURING OF PARTIAL DISCHARGES

By adding a coupling quadripole (option), the coupling capacitor type KK(F) can be used for measuring partial discharges. Various coupling quadripoles can be used. Digital or analogue PD detectors can then be used depending of the customer's needs. Please consult the Tettex General Catalogue for more information.



Digital partial discharge detector type DDX® 9101

MEASURING OF CAPACITANCE AND TAN δ

The standard capacitors types NK are used in conjunction with C & tan δ bridges for accurate measurements of capacitance and tan δ values. Digital or analogue bridges can then be used depending of the customer's needs. For more details, see the Tettex General Catalogue.

Capacitance and tan δ bridge type 2840

The SF6 insulated standard capacitor is used together with a C & tan delta measuring bridge (e.g. Tettex 2877) as a comparison standard for accurate measurements of the capacitance and tan delta of HV equipment. The SF6 insulated standard capacitor is designed for indoor service and is of mobile design.

Standard capacitor family from 5 kV to 800 kV

Test system 350 kV, 2 A with damping resistor

ORDER TEXT

Description	Code
■ Complete basic system	ACS ... kV, ... A PSZ ... kV, ... A
■ HV transformer	PZ(T)(L) ... kV, ... A
■ Switching and regulating cubicle	ST ... kVA
■ Compensating reactor	KDL ... kVA
■ Control unit with set of control and measuring cables, 20 m	OT 276 in desk top housing or OT 248 in desk top housing
■ Voltage measurement	DMI 551 needed with controls OT 276 incl. in OT 248 and OT 257
■ Low voltage protection device (only included for systems 600 kV and above)	NSP 400 or NSP 1000
■ One set of operating instructions and test reports	
Options	
■ Power line & ■ HV filters	NLFA ... V, ... A F ... mH, ... A
■ Computerised control unit with set of control and measuring cables, 20 m	OT 257 with desk and mini-rack
■ Standard capacitor	NK ... kV, ... nF
■ Technical services	DEL
■ Partial Discharge detectors ■ C & tan δ measuring bridges	several models available, please see the Tettex General Catalogue
■ Other possibilities	please contact us

LIST OF LEAFLETS

AC voltage test systems up to 1800 kV, 40 A	E 152.51
Instrumentation for Partial Discharge, C and tan δ, accuracy and resistance	Tettex General Catalogue
Compact Digital Partial Discharge DDX® 9101	
Haefely Test AG offers also a complete range of impulse test systems for both impulse voltage and impulse current applications.	

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