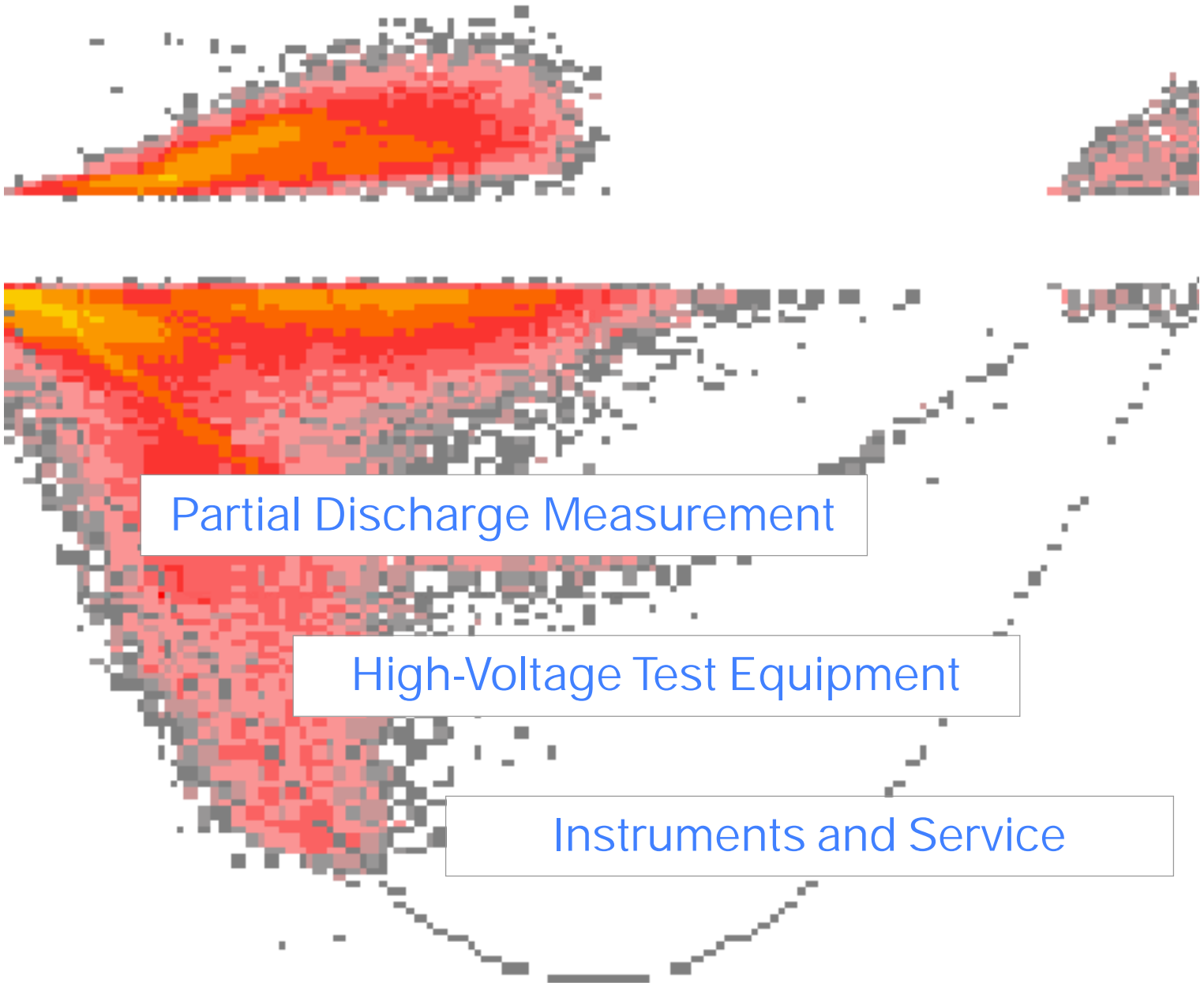
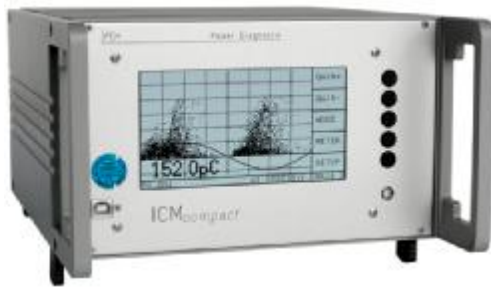


Diagnosis
Monitoring
Quality Control
Research and
Development



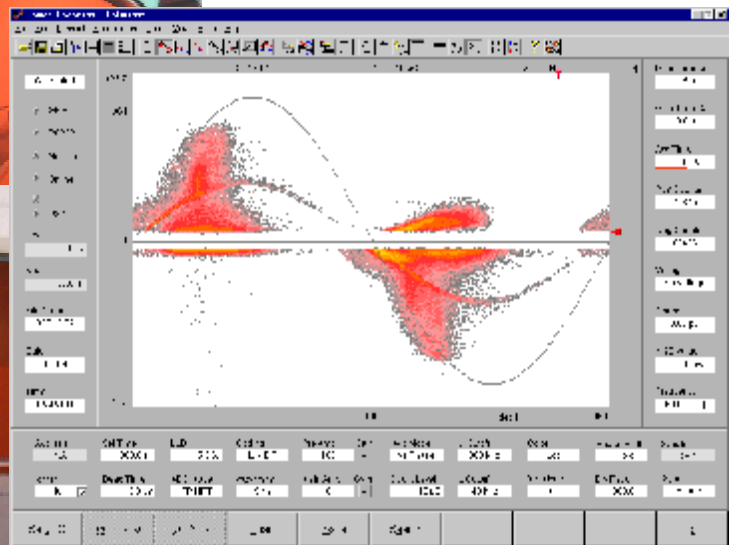
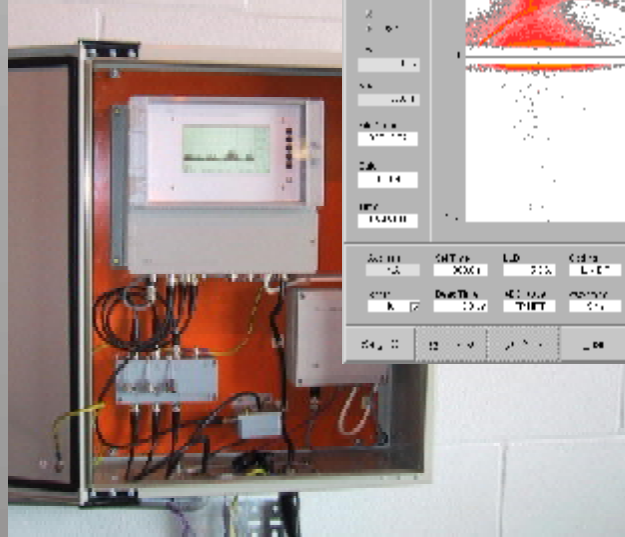
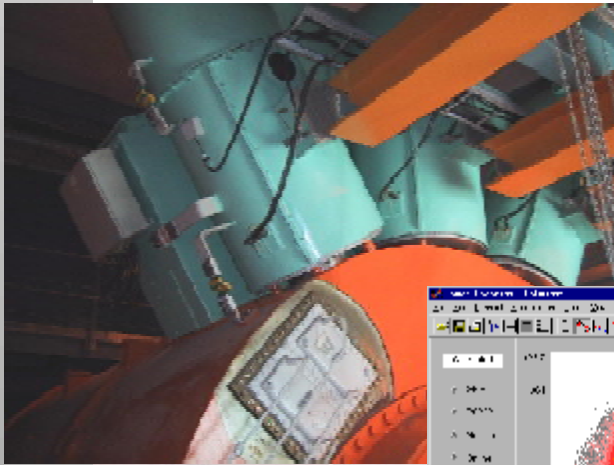
Company Profile

Power Diagnostix Systems GmbH provides quality instruments and engineering services for high-voltage diagnostic applications. Power Diagnostix has built a solid reputation since market introduction of our partial discharge detectors in early 1993. Our ICMseries of digital partial discharge detectors is used for evaluation of electrical insulation by electric utilities, manufacturers, and research institutes world-wide.



In addition to digital partial discharge detectors, Power Diagnostix produces instruments for commissioning tests of GIS systems, automated control of high-voltage tests, fiber optic connections for analog signal transmission between instruments and sensors, and for other applications in high voltage. All of our instruments and specialized software products are developed in Aachen, Germany.

Agents worldwide work in direct contact with us and our customers to find optimized solutions for their applications. The company's principal engineers are active in several scientific committees.



Instruments

Power Diagnostix Systems GmbH produces versatile, top-quality instruments for high-voltage diagnostic applications. Power Diagnostix ICMseries of partial discharge (PD) detectors is used worldwide for evaluation of electrical insulation used in electricity generation, transmission and distribution, in manufacturing, in research, and in industry. In addition to partial discharge detection equipment, Power Diagnostix produces instruments for fiber optic transmission, GIS fault location, $\tan \delta$ measurements, and high-voltage test control.



ICMsystem 5

The ICMsystem is a digital partial discharge detection system. The instrument is completely controlled by software using a GPIB, USB, TCP/IP, GSM Modem, fiber optic or direct serial link.



ICMsys8 7

The ICMsys8 is a true-parallel 8-channel acquisition system, while offering all features of the single channel ICMsystem. It is designed for acceptance tests on large power transformers and other application requiring parallel acquisition.



ICMcompact 9

The ICMcompact is a stand-alone partial discharge detector often used for quality assurance. Among other options, the ICMcompact can be equipped with circuits to perform partial discharge location in power cables.



SPECcompact 11

The SPECcompact is a narrow- and broad-band partial discharge detector with selectable center frequency. The unit offers as well spectrum analysis up to 10 MHz and a selectable bandwidth of 9 kHz or 270 kHz.



ICMmonitor 13

The ICMmonitor is an instrument for continuous on-line monitoring of partial discharge activity in high voltage equipment. The instrument tracks changes in key discharge quantities for storage in trending diagrams and for triggering user-settable alarms. TCP/IP, Modem, fiber optic or direct serial links enable remote access and full remote control.



SPECmonitor 15

The *SPECmonitor* is a partial discharge analyzer comprising a spectrum analyzer, an acoustic detector, and a conventional partial discharge monitor in one instrument.



AIAcompact 17

The *AIAcompact* is a portable unit for acoustic partial discharge measurement on GIS, transformers, and cable accessories. Optionally, the unit can be equipped with circuits for UHF measurements.



RIVmeter 19

The *RIVmeter* is an instrument for the measurement of 'Radio Influence Voltage' according to NEMA 107-1987 and other relevant standards.



ICMflex 21

The *ICMflex* instrument family, introduced in 2008, bases on the latest concept where the entire acquisition hardware is placed on high voltage potential. The instruments are fully remote controlled via high speed Bluetooth or fiber optic communication.



TDAcompact 23

The *TDAcompact* is a loss factor meter. The capacitance C_x , the $\tan\delta$, and the voltage are derived by digitally processing the currents of the test capacitor and a reference capacitor.



HVcompact 25

The *HVcompact* is a high voltage meter with an auto-ranging oscilloscope display of the voltage waveform. The unit displays \hat{U} , $\hat{U}/\sqrt{2}$, U_{rms} , frequency, and crest factor.



STEPcompact 27

The STEPcompact allows running high voltage test sequences. The instrument controls via fiber optic cable the 'UP' and 'DOWN' contact of the motor driven voltage regulator (VARIAC). The instrument detects incipient breakdown.



HVcontrol 29

The HVcontrol offers all features that are required to manually control any high voltage test set. Current limits that trip the main circuit breaker can be set for I_{prim} and I_{sec} .



FOsystem 31

The FOsystem is a complete set of instruments for fiber optic transmission of analog signals from different sensors (e. g. temperature, pressure, acoustic, voltage, current). The signal bandwidth covers DC up to 10 MHz.



ATTanalyzer 35

The ATTanalyzer supports commissioning of gas-insulated switchgear yards. Signals of up to 16 acoustic sensors can be connected. Precise localization of breakdown within the GIS is provided by comparing the travel-time of the breakdown sound to the various sensors.



GISmonitor 37

The GISmonitor offers parallel, real-time acquisition of UHF PD signals captured by any embedded or external sensors permanently installed on gas-insulated switch gear (GIS). The system builds on compact 8-channel sub-modules to allow flexible configuration.



Preampifiers & Measuring Impedance 39

When a quadrupole and a coupling capacitor are used together as the coupling device, high voltage is applied both to a test object and to the coupling capacitor in parallel with the test object. A quadrupole (sometimes called a measuring impedance) can then be placed in series with either the coupling capacitor or in series with the test object. Preampifiers serve to condition, filter, and amplify the PD signal to be measured.



Coupling Devices & Filters 43

Coupling capacitors with built-in quadrupoles are used to capture the PD signals and to synchronize the measurement to the test frequency. Additionally, rugged coupling capacitors are used for permanent installation for monitoring purpose.



Sensors and Miscellaneous 45

We offer various sensors for temporary or permanent installation with gas-insulated switchgear (GIS), cable accessories, and power transformer. For existing measurement taps of transformer bushings a series of bushing adapters is offered.



Calibrators (CAL) 49

We offer a variety of calibrators ranging from 1pC to 50 nC. Due to their high bandwidth the calibrators are suitable for impulse reflectometry on cable systems and for GIS testing. New charge calibrators are shipped with the DKD calibration certificate to ensure the traceability to international standards.



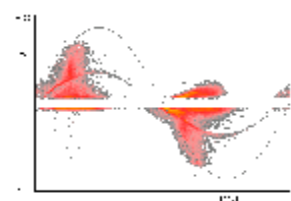
Applications 51

Using the range of instruments with the different applications, such as rotating machines, power transformers, cable systems, or GIS and GIL, requires considering the special conditions of each field.



Services 61

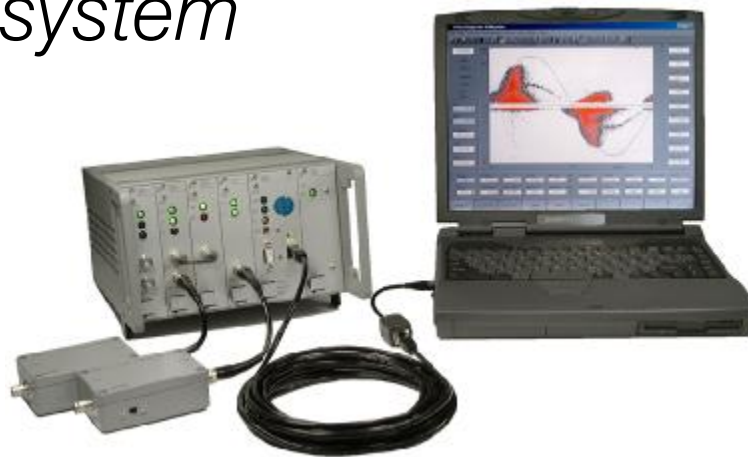
We offer on- and off-line PD analysis on rotating machines, transformers, cables, etc. Instruments can be provided temporarily on a rental base. Furthermore, an on-site DKD-calibration of HV_{AC} measurement systems up to 100 kV can be performed.



Typical PD Pattern 63

With the PD pattern (ϕ -q-n pattern), each acquired impulse is sorted and counted with respect to its phase angle and acquired amplitude. The pattern contains information of various properties of the defect causing the discharge.

ICMsystem



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

Partial discharge (PD) measurements are a proven method for effective, non-destructive evaluation of electrical insulation. The Power Diagnostix ICMsystem provides high-resolution digital PD patterns for characterization of defects in high voltage insulation systems.

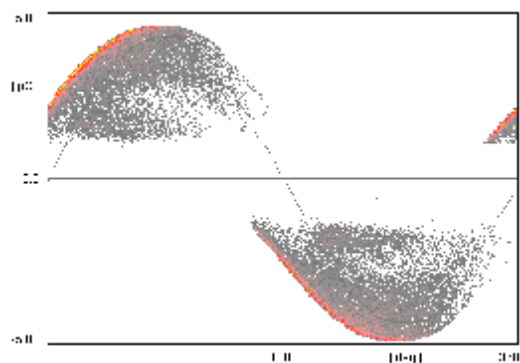
Assorted coupling devices, including quadrupoles, coupling capacitors, and current transformers, are available to sense the PD signal in the object under test. Like the other instruments in

The key to the versatility of the ICMsystem is its modular design.

Versatility

The key to the versatility of the ICMsystem is its modular design. The ICMsystem can be matched up with a variety of special accessories that adapt it to virtually any high-voltage testing environment. A wide range of external preamplifiers provides control of the frequency range in which PD activity is detected, from 40 kHz up to 2 GHz.

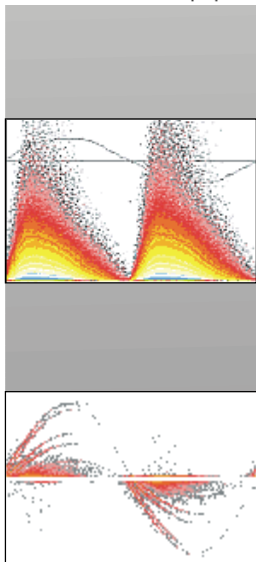
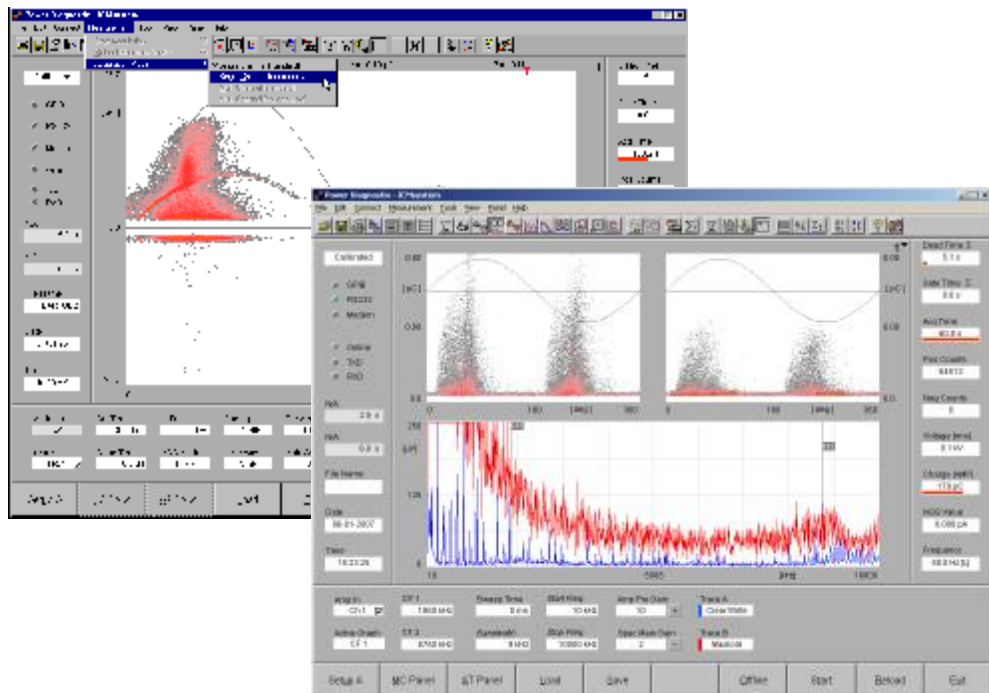
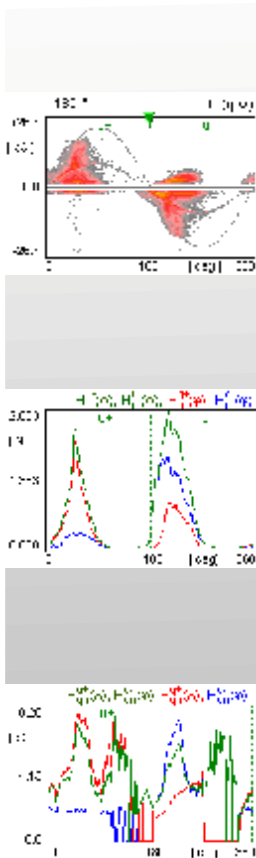
the ICMseries, the ICMsystem provides effective noise gating that blocks phase-stable noise as well as noise independent of the applied voltage cycle, allowing the ICMsystem to be used in noisy environments without losing significant PD data. Appropriate selection of a preamplifier can assist further in achieving a high signal-to-noise ratio.



Phase-Resolved PD Pattern

PC Software

The operating parameters of the ICMsystem are fully computer controlled, making it simple to use with standard Power Diagnostix software. The actual recording of PD patterns is independent of the PC, so the performance of the ICMsystem is unaffected by speed limitations of the PC or communications.



The ICMsystem's PC software includes convenient options for in-depth analysis and printing of stored PD patterns.

Special Applications and Options

For applications such as DC testing or stepped high-voltage testing, the ICMsystem allows recording PD activity versus time (sequentially) instead of versus phase angle. Options such as a multiplexer module, fiber optic bus, and built-in modem further extend the capabilities of the ICMsystem. The multiplexer module, working with ICMmux software, allows easy selection among eight channels for PD measurement. The fiber optic bus provides enhanced protection in hazardous measurement conditions and

can link widely separated components of a test setup. The modem option permits remote access to data and control of the ICMsystem. The full command set of the ICMsystem is provided with the device also, so users may create custom programs to control the ICMsystem for highly specialized applications or for integration into an overall high-voltage test control program.

Options:

- Multiplexer
- Built-in spectrum analyzer
- RIV measurement
- Cable fault location
- Acoustic PD location

Giving users complete access to detailed control parameters and the ability to download and analyze PD patterns on a PC makes the ICMsystem the ideal instrument for advanced analysis of phase-resolved partial discharge patterns, whether in research, utility, or industrial applications.

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 Fax: + 49 241 79521

ICMsys8



The ICMsys8 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 for each channel, true parallel acquisition of the discharge magnitude of eight channels is achieved. The instrument can be equipped with optional features like RIV or acoustic PD measurement.

Using the eight-channel ICMsys8 greatly simplifies partial discharge acceptance tests on large power transformers. With the true parallel acquisition of the partial discharge activity on eight channels, the overall testing period is substantially shortened.

independent channels for the measurement and sampling of the AC voltage signal provided by the quadrupole.

True eight-channel partial discharge acquisition

Independent Channels

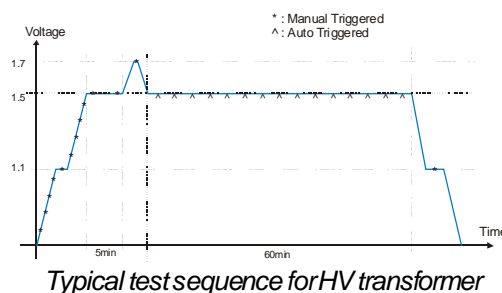
For each of the eight partial discharge measurement channels an independent quadrupole, pre-amplifier, and amplifier plug-in is provided. Internally, the system controller processes the discharge readings acquired for each channel in a true bipolar peak amplitude acquisition. Optionally, the PD readings can be weighted according to IEC60270-2000. Besides the eight partial discharge channels, the instrument offers eight

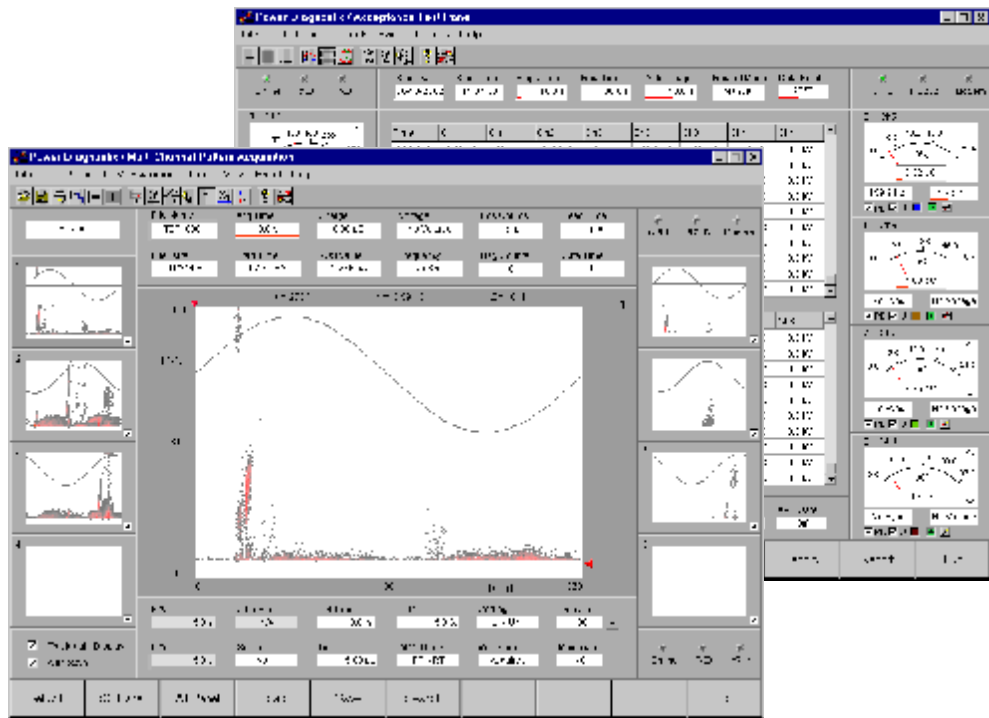
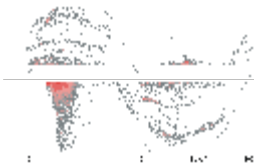
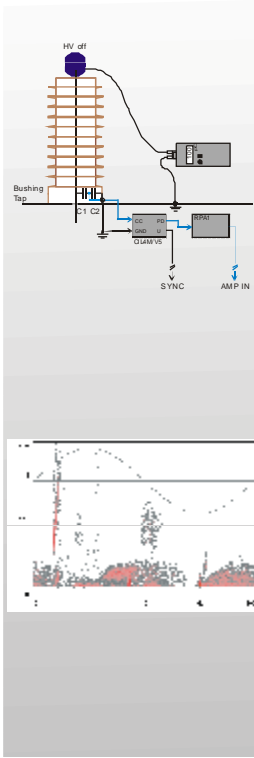
Pattern Acquisition

In addition to the parallel acquisition of the PD activity for the meter and strip-chart displays, the pattern acquisition core known from the standard ICMsystem offers the defect identification capabilities of the phase-resolved partial discharge analysis. The influence of power frequency harmonics on the PD pattern, often found with power transformers, can be clearly identified, as the waveform of the AC voltage is available for each channel.

Software

The control software to run the eight-channel ICMsys8 offers manual and automatic modes for the acceptance test.





Reporting is simplified with MS Word and plain text output formats. The reports are based on user-selectable templates.

such as multi-channel consecutive pattern acquisition, movie-like replay, or statistical evaluation, for instance.

In acceptance test mode, the software shows eight meter displays, each indicating PD level, voltage, and frequency of the specific channel. With the center display, the automatically or manually triggered values are presented in list mode or as a strip-chart. Further, during calibration, the cross-coupling matrix between the channels is built up, which eventually can help locating the source of PD activity. Additionally, the ICMsys8 software provides the user with all the features known from the standard ICMsystem,



ICMsys8 installed in a control room

The ICMsys8 for power transformer acceptance testing is the first commercially available partial discharge detector with true parallel acquisition on eight channels. The ICMsys8 and its software greatly simplify the testing procedures and, thus, reduce the time the transformer needs to stay in the acceptance test lab.

ICMcompact



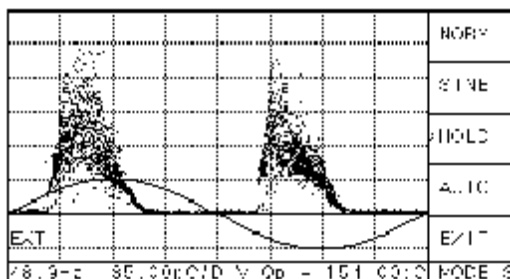
ICMcompact - Digital Partial Discharge Detector

Instruments

The ICMcompact is part of the Power Diagnostix ICMseries 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.

Stand-Alone Instrument

Partial discharge (PD) measurements are a proven method for effective, non-destructive evaluation of electrical insulation. The Power Diagnostix ICMcompact provides a simple push-button interface and on-screen menus in an embedded LCD panel. The LCD display modes include a simple PD charge meter with adjustable “needle” sensitivity, monochrome phase-resolved PD patterns for characterization of defects, and a scope-like display showing phase-summed charge pulses superimposed with the applied voltage wave.



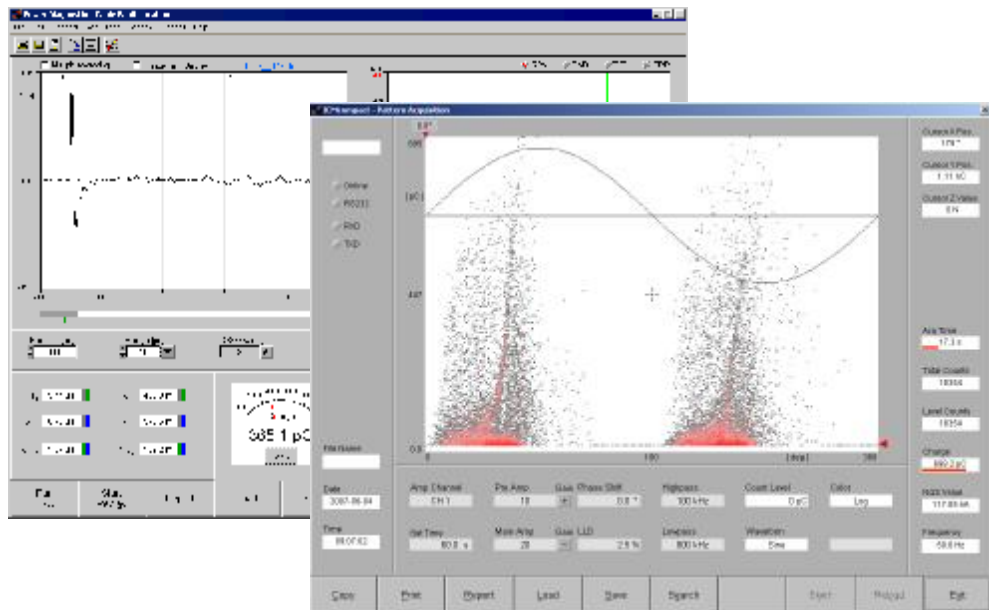
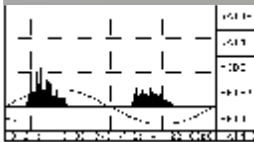
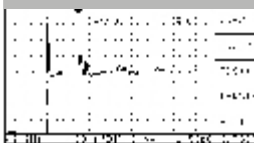
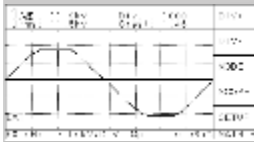
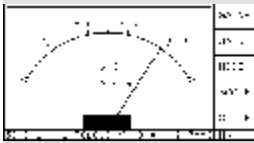
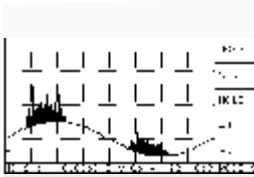
Phase-resolved PD pattern

Although the ICMcompact is an autonomous unit, it can be connected to a computer installed with Power Diagnostix software to capture screenshots or to implement remote control of the unit.

Applications

Instantly displaying information in an intuitive interface, the ICMcompact is a good choice for applications such as quality control tests in manufacture of electrical products, and for quality assurance of industrial and utility equipment from capacitors and bushings to gas-insulated switchgear and others. A wide range of accessories adapts the ICMcompact to specific testing applications and noise conditions.

The ICMcompact equipped with an optional DSO board can be used to locate partial discharge defects in power cable. Using time domain reflectometry, in which the PD and its “echoes” travel the length of the cable under test, the ICMcompact provides the proportional distance of the PD fault along the cable.



The ICMcompact offers convenient on-site testing of equipment such as cable accessories or sensors installed with gas insulated switchgear, for instance. Generally, this unit can be used with the full range of the ICMseries preamplifiers, covering the IEC60270 standard and ultrasonic frequencies up to the UHF range (20 kHz - 2 GHz).

To adapt the basic ICMcompact unit to suit special measurement requirements, it can be equipped with various options:

- Voltage measurement. Adds the HVM oscilloscopic display showing the waveform of the high voltage and calculates \dot{U} , $\dot{U}/\sqrt{2}$, U_{rms} etc.
- Cable PD location. An additional DSO board samples the PD signal at 100 Msample.

- Analog gating to cancel external disturbance. This option offers sensitive measurements even in noisy environments.
- TTL-Gating. Unconditioned gating on an external TTL signal to combine the ICMcompact with IGBT driven resonant high voltage test sets.
- UHF measurements on GIS. Comes with a logarithmic display for the UHF preamplifier RPA6C
- MUX4. Four-channel multiplexer for testing three-phase equipment, such as power transformers. For each channel the unit maintains an individual setup and calibration.
- MUX12. With this option a remote 12-channel switching box offers cost-efficient acceptance testing on large power transformers.
- AUX8. For long-term testing up to eight additional parameters can be captured as 0(4)-20 mA or 0-10 V signals.

The easy portability, simple operation, and flexibility of the Power Diagnostix ICMcompact make it a good choice for routine PD testing in a variety of utility and industrial applications.

SPECcompact



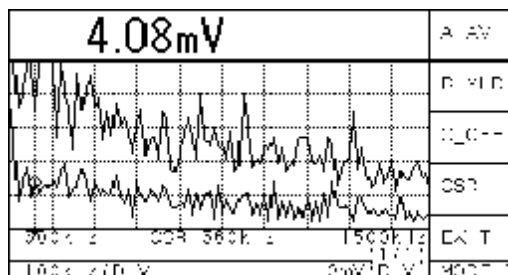
The SPECcompact comprises a spectrum analyzer, a partial discharge (PD) detector and an RIV meter in one instrument. This combination enables PD measurements even with a large background noise e.g. in non-shielded test areas.

Observing the frequency spectrum of a harshly disturbed PD signal allows selecting frequency bands with less 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.

There are three main display modes and a high voltage meter (HVM) as optional function:

SPEC Mode

The SPEC mode shows the frequency spectrum of the input signal with a selectable span of up to 10 MHz. Three spectrum traces of the current input channel can be stored, compared and analyzed. A variable cursor serves to set the center frequency for the PD pattern acquisition.



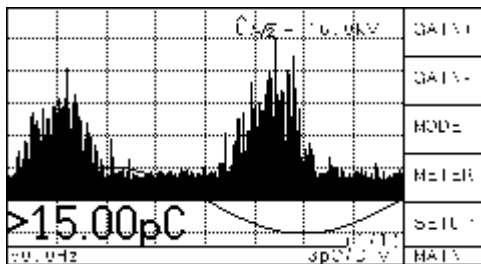
Frequency spectrum
Spectrum scan display

The SPECcompact comes with one, three or eleven channels. A multiplexer allows to directly select the input signal.

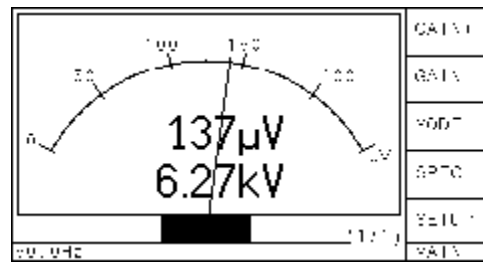
Measuring partial discharge within noisy environment

SCOPE Mode

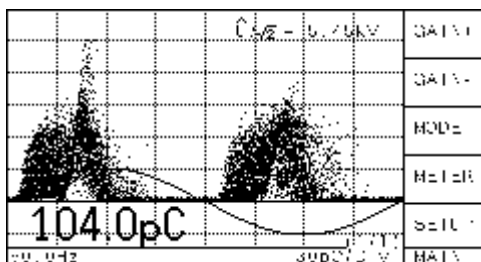
The SCOPE mode displays the PD pattern versus phase as known from the ICMseries. The SYNC frequency ranges from 10 to 500 Hz. The PD activity can be shown as vertical bars or as dots to get a so called PD pattern.



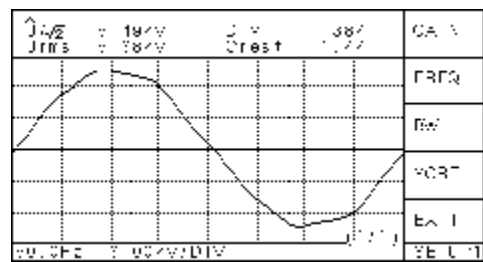
SCOPE mode (NORM)



METER mode (RIV & HVM)



SCOPE mode (HOLD)



HVM mode

METER Mode

The METER mode can be chosen to visualize the PD activity like older analog meters. Three modes are available for the charge value in 'pC' (FAST, NORM, IEC270) and one for the voltage value in 'μV' (RIV).

tion or power frequency harmonics, for instance, are clearly identified with this display. The screen is automatically synchronized with the measured voltage and the amplitude deflection is controlled by an auto-range function.

HVM Mode

The high voltage meter (HVM) is an optional function to observe the measured voltage waveform. The HVM shows the voltage supplied at the SYNC input. The input voltage is sampled in high resolution and one cycle is displayed as an oscilloscopic trace. Any distortion of the high voltage due to transformer core saturation



Accessories for RIV measurement

The SPECcompact comprises a spectrum analyzer, a partial discharge (PD) detector and an RIV meter in one instrument. This combination enables PD measurements even with a large background noise e.g. in non-shielded test areas.

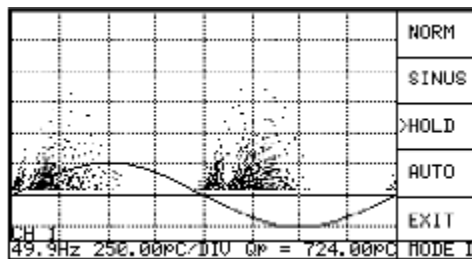
ICMmonitor



The ICMmonitor is part of the Power Diagnostix ICMseries of digital partial discharge detectors. The ICMmonitor 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 permanent, continuous on-line monitoring of rotating machines, cable systems, power transformers, and gas-insulated switch gear (GIS).

Partial discharge (PD) measurements are a proven method for effective, non-destructive evaluation of electrical insulation, preventing expensive unplanned outages by detecting insulation problems before they can cause breakdowns. The Power Diagnostix ICMmonitor is a non-invasive digital PD detector for permanent installation and continuous monitoring of medium and high-voltage insulation.

play for characterization of defects, a scope-like display showing phase-summed charge pulses superimposed with the applied voltage wave, a time trending display, and a monitoring display showing bar graphs of two key partial discharge quantities (Qp and NQS). Qp is the apparent charge value of the PD activity, and NQS is the absolute discharge current obtained by integrating the discharge values (summing up the total charge moved and dividing by the time interval, $Q/t = [As]/[s]$).



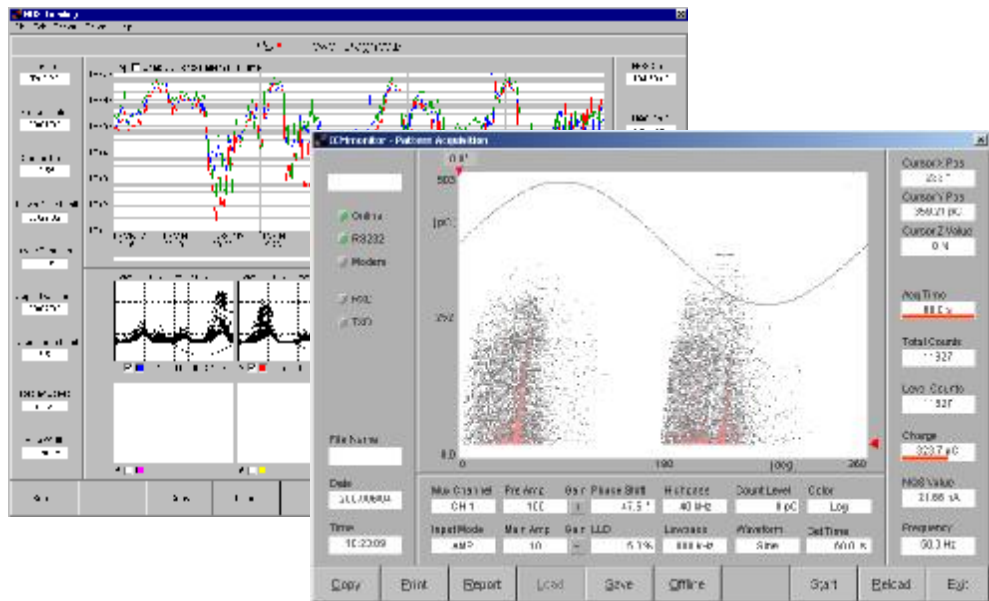
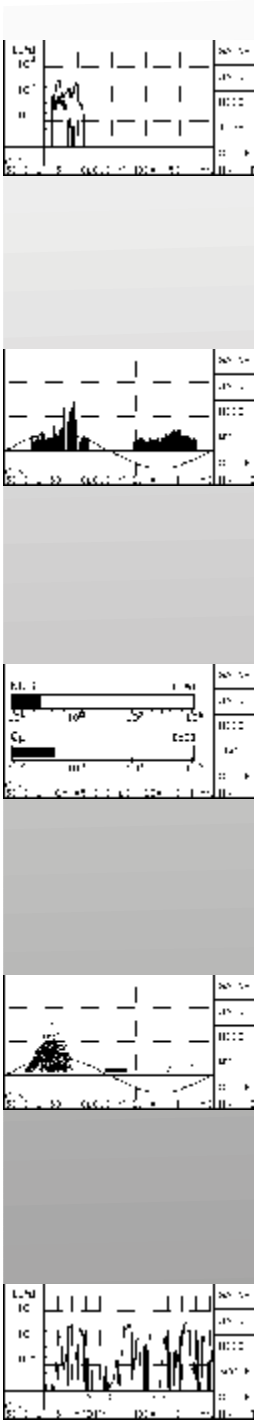
Monochrome PD pattern display

Embedded Display

The ICMmonitor has a simple push-button interface to navigate on-screen menus in an embedded LCD panel. The LCD display modes include a monochrome phase-resolved PD pattern display

Noise Rejection

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 noise for certain portions of each applied high voltage wave. Additionally, appropriate choice of the external preamplifier can limit noise by detecting PD in a frequency band outside the range of the noise.



Alarms and Trending

Users can set alarm levels of NQS or Q_p that will trigger when those values are exceeded. A triggered alarm will sound, appear on the LCD display, and activate an output on the ICMmonitor that can be used to drive a relay for interfacing with a local alarm system. The ICMmonitor also collects and displays PD data over a specified time interval for easy trending and observations of changes in the Q_p and NQS levels in the monitored system. Optionally, up to eight DC signals such as temperature or load can be added to this trending.

Telemonitoring

Although the ICMmonitor is an autonomous unit, it can be connected to download data or to implement remote control of the unit. With its built-in TCP/IP interface or analog modem, the ICMmonitor can be controlled and ob-

served 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. The ICMmonitor software automatically maintains the trending information as well as the phase-resolved pattern of a multitude of ICMmonitor units.



Portable ICMmonitor with modem

The multifunctional ICMmonitor, with its embedded display, convenient trending, and settable alarms, is an ideal solution for continuous on-line monitoring of rotating machines and other electric devices in industrial and utility applications.

SPECmonitor



The SPECmonitor is a partial discharge (PD) measurement device comprising a spectrum analyzer, an acoustic detector, and a conventional PD monitor in one instrument. This combination enables PD measurements even with high levels of background noise e.g. on power transformer within substations or power plants.

Observing the frequency spectrum of a harshly disturbed PD signal allows to select frequency bands with less disturbances. Using this center 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 greatly expands the measurement possibilities when analyzing the insulation systems in a noisy environment.

In the standard version, the SPECmonitor comes with an eight or four channel multiplexer to directly select the input signal. The instrument provides five different display modes and several interfaces like e.g. TCP/IP or modem for remote control and diagnosis.

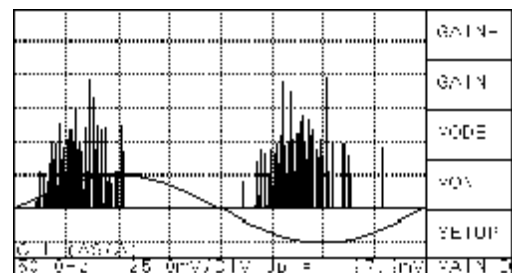
SCOPE Mode

The SCOPE mode displays the PD pattern versus phase as known from the ICMseries. Hereby, the selected center frequency and bandwidth of the SPEC mode is used, in order to disregard frequency ranges occupied with disturbances. The SCOPE mode offers viewing an oscilloscopic display (below) as well as a pattern display.

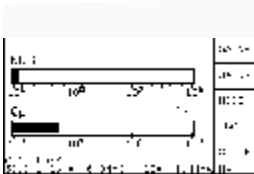
Measuring partial discharge within noisy environment

SPEC Mode

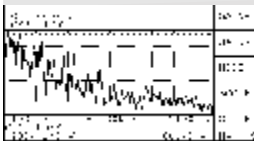
The SPEC mode shows the frequency spectrum of the input signal up to 10MHz. Three traces for the current input channel allow storing, comparing and processing of this spectrum. The bandwidth of the demodulated signal can be set to 9 kHz or 270 kHz, respectively.



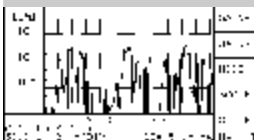
Scope display



Monitoring display



Spectrum display



Trending display



Acoustic sensor with magnetic holder



Bushing adapter and coupling unit

MON Mode

The monitoring display allows to set alarm levels of NQS or Qp that will trigger when those values are exceeded.

TIME Mode

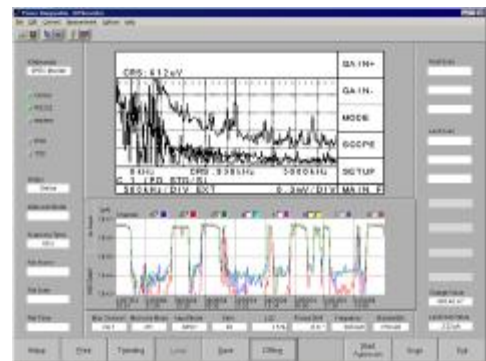
Additionally, the SPECmonitor collects and displays PD data over a specified time interval for easy trending and observations of changes in the Qp and NQS levels of the monitored system.

Software

Besides this autonomous functions, the instrument can be connected to a computer via serial interface, modem, or TCP/IP. A special software allows the remote control of the instrument and the download of the stored data. An autoscan function takes the trending information as well as the phase-resolved pattern of one or multiple units.

Accessories

It is possible to connect acoustic sensors (AS), UHF sensors, or the standard coupling unit from the bushing test tap to the SPECmonitor.

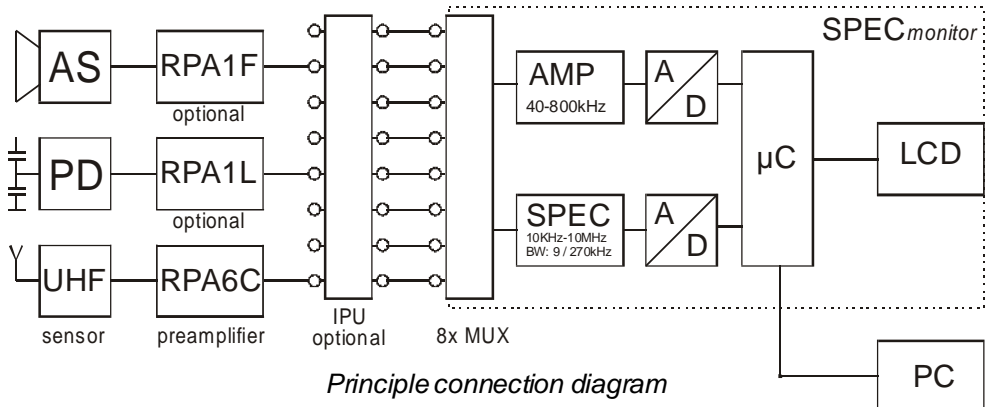


SPECmonitor software

Different preamplifiers like RPA1F, RPA1L or RPA6C can be used in case of weak signals or to drive long cable lengths.



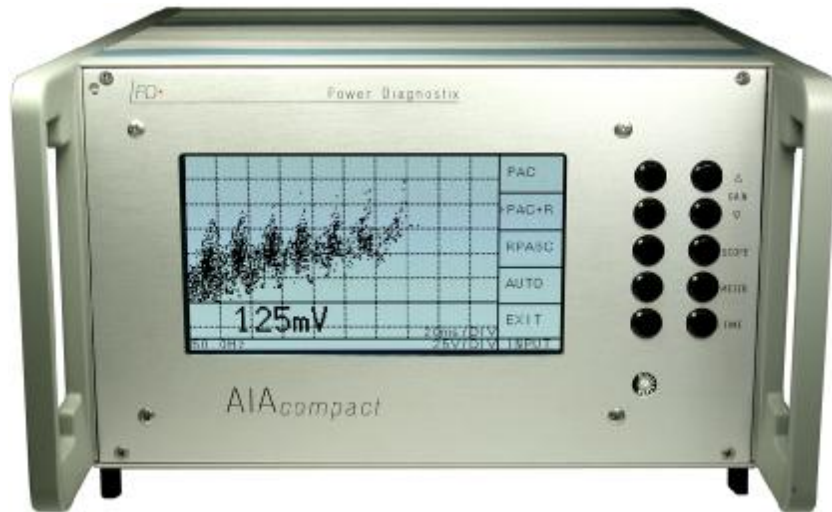
SPECmonitor in a full 19" rack



Principle connection diagram

Combining a spectrum analyzer and the multifunctional ICMmonitor greatly expands the measurement possibilities of the SPECmonitor. This combination allows PD monitoring even with a large background noise and with different sensors connected.

AIAcompact



AIAcompact - Acoustic Insulation Analyzer

Instruments

The *AIAcompact* is a portable unit for in-service acoustic partial discharge measurements on gas-insulated switchgear (GIS), transformers, and cable accessories. The instrument adapts to a variety of piezo-electric acoustic sensors and is supplied with a versatile sensor fixture. Additionally, the *AIAcompact* allows partial discharge measurements on embedded or external UHF sensors.

Acoustic partial discharge measurements can be easily applied on gas-insulated switchgear and other high voltage equipment without the need of interrupting the operation. Such in-service measurements help to identify internal imperfections of the insulation system, which may lead to breakdown and system failure in the future.

Easy-to-apply substation condition assessment

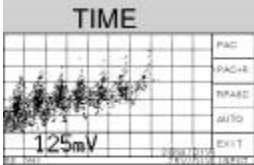
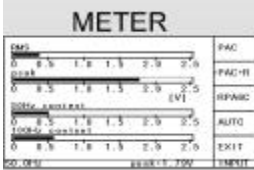
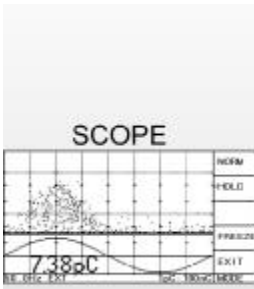
Acoustic partial discharge measurements rely on the close acoustic contact of the area producing the discharge to the point of access, where the sensor is placed. Most of the partial discharge activity in GIS offer such a good contact and, hence, can be detected at a good sensitivity.

Therefore, discharges from sharp points or cones as well as discharge activity

from delaminations can be identified at a sensitivity, which is mostly comparable to the conventional electrical detection according to the IEC60270.

For some defect types, such as the so-called hopping or bouncing particles, the acoustic detection is by far superior to the electrical detection. Such free particles can cause flashover and severe breakdown especially in the initial phase after erection or maintenance of gas-insulated switchgear.

Based on the proven hardware core of the *ICMcompact*, the *AIAcompact* offers automatic detection of the sensor or preamplifier used. Normally, the instrument is operated with acoustic sensors with remote supplied embedded preamplifiers directly connected to the signal input. Alternatively, the RPA1D, known from the *ICMsystem*, can be inserted close to the sensor to boost the signal, which can be mandatory, in case longer signal cables are used or in case of low-level measurements.



UHF measurements on embedded or external sensors are possible with the use of the RPA6C, a logarithmic preamplifier, which covers 300 MHz - 2 GHz. As with the other preamplifiers, the *AIACOMPACT* automatically detects the RPA6C and changes into the logarithmic display for the UHF detection. Generally, the instrument offers three main display modes, which are selected using dedicated control buttons: Scope, Meter, and Time.

Scope

In Scope mode, the *AIACOMPACT* shows the phase-resolved partial discharge signal or pattern as the standard *ICMCOMPACT*. Here, the 'Freeze' function allows keeping a captured phase-resolved partial discharge pattern for further evaluation or for taking screenshots.



Meter

The Meter mode offers four bar graph displays showing derived quantities of the captured activity. The graphs display the RMS and the peak PD level, as well as their 50 Hz (60 Hz) and 100 Hz (120 Hz) content. The instrument automatically synchronizes to the line frequency.

Time

Within the time mode, the *AIACOMPACT* displays five or ten AC cycles triggered by a partial discharge event. Thus, this display shows the pattern of consecutive partial discharge events and, hence, offers a clear identification of bouncing particles and the severity of their activity.

All captured pattern and displays can be transferred to a notebook via an RS232 interface using the optional *AIACOMPACT* software.

Offering easy-to-use acoustic partial discharge analysis of gas-insulated switchgear (GIS) and other high voltage equipment plus the optional analysis on embedded or external UHF sensors makes the *AIACOMPACT* the ideal solution for convenient in-service substation condition assessment.

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RIVmeter



RIVmeter - Radio Influence Voltage Meter

Instruments

The *RIVmeter* is an instrument for the measurement of 'Radio Influence Voltage' according to the relevant standards (NEMA 107-1987, ANSI 63-2-1996, VDE 876, DIN EN 55016-1-1). The instrument has a bandwidth of 9 kHz and a tunable center frequency of 10 kHz - 10 MHz. Technically, the *RIVmeter* is a selective μV -meter. However, the meter reading is weighted according to the CISPR weighting curve, whereas the repetition rate has a strong impact on the reading. The *RIVmeter* is an ideal instrument to replace outdated RIV measurement instruments in a transformer testing lab, for instance.

Some routine PD measurements are still done according IEEE Standards requiring the measurement of 'RIV' (RIV = Radio Influence Voltage). The RIV value is given in μV (interference voltage). A 'narrow band' filter performs a quasi-integration of the PD pulses with a quasi-peak detection at the center frequency. This center frequency can be adjusted between 10 kHz and 10 MHz. The narrow-band pass filter allows to suppress external noise e.g. in non-shielded laboratories by varying the center frequency of the filter.

Two factors determine the RIV in μV : The transferred charge and the repetition rate of the PD impulse (number of PD pulses per second). Because of this

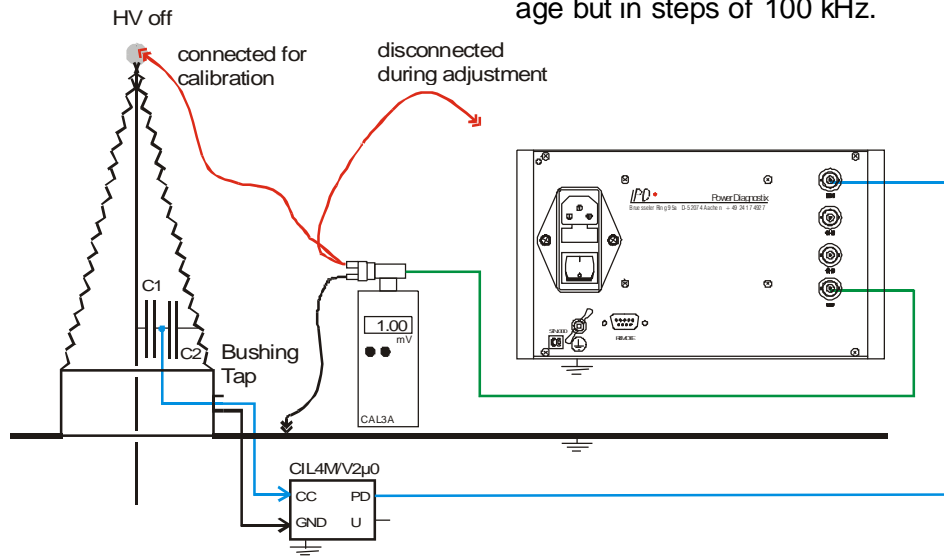
proceeding, a direct translation of the measured RIV values (μV) into values of apparent charge in pC is not possible.

New RIVmeter supporting old standards

Historically, the RIV technique is based on measurement receivers to estimate the disturbance of communication lines. Thus, properties of those instruments then available became part of the NEMA standards. However, both the 9 kHz bandwidth and the CISPR weighting curve put emphasis on some partial discharge activity, while they tend hiding others.

The calibration of the RIV measurement is done using an RIV calibrator, injecting a sine wave of typically 100 μ V into the bushing. The multiplexer of the RIVmeter is used to conveniently determine the correction factor according to NEMA 107-1987 and other standards. Here, the unit compares the voltage injected, i.e., loaded by the bushing's impedance, with the voltage detected at the bushing tap

to automatically determine the k-factor. This correction factor is then stored independently for each channel during calibration. The standard calibrator for RIV calibration, CAL3A, offers a selectable frequency range of 600-1350 kHz in steps of 50 kHz. The output voltage covers 10 μ V to 10 mV in 1-2-5 steps. The CAL3B calibrator offers a frequency range of 400 kHz to 1.9 MHz with the same output voltage but in steps of 100 kHz.



Old Stoddart NM-25T



Old Siemens B83600-B40



CAL3A for RIV calibration



RIVmeter rear panel

The RIVmeter is an instrument for the measurement of 'Radio Influence Voltage' according to NEMA 107-1987 and other relevant standards. It is the ideal instrument to replace outdated RIV measurement instruments in a transformer testing lab.

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ICMflex



The ICMflex high voltage instrument family offers inherent operator safety and greatly simplifies distribution class cable testing and other field tasks involving partial discharge and $\tan\delta$ testing. With the unique concept of the ICMflex instruments, the entire acquisition hardware is placed on high voltage potential right at the position where the signals are. Thus, no signal cables are needed, as the instrument is fully self-contained and battery operated. The instruments are fully remote controlled via high speed Bluetooth or fiber optic communication.

Unique Concept

The ICMflex instrument family is available with different options and for different voltage levels. Additionally, the self-contained ICMflex acquisition unit can be placed on top of any third-party coupling or reference capacitor. The option TD offers $\tan\delta$ and power factor (PF) measurements. The option PD provides partial discharge measurements according to the IEC60270, whereas the option PDL includes partial discharge location for power cables.

Wireless signal transmission via Bluetooth communication

Finally, the option TF covers a high voltage T-filter to sufficiently de-noise a high voltage supply for sensitive partial discharge measurements. The detachable Li-MH battery provides 10 hours of continuous operation, while a second battery is charged. Any high voltage AC

source can be used including resonant test sets and VLF high voltage sources.

Testing distribution-class cables in a field environment becomes an easy and inherently safe task. The ICMflex unit is simply placed between high voltage source and the cable to be tested – no further leads required. The ICMflex unit can be equipped with a high voltage filter to accommodate noisy high voltage sources. Thus, with one unit requiring only high voltage and ground connection all essential measurements on laid power cable are performed in one step: $\tan\delta$, partial discharge, and partial discharge location.

Off-line testing of generator and motor stator coils is simplified in the same way. Using any high voltage source, the critical AC measurements on the stator coil are done simultaneously: $\tan\delta$, PF, and partial discharge.



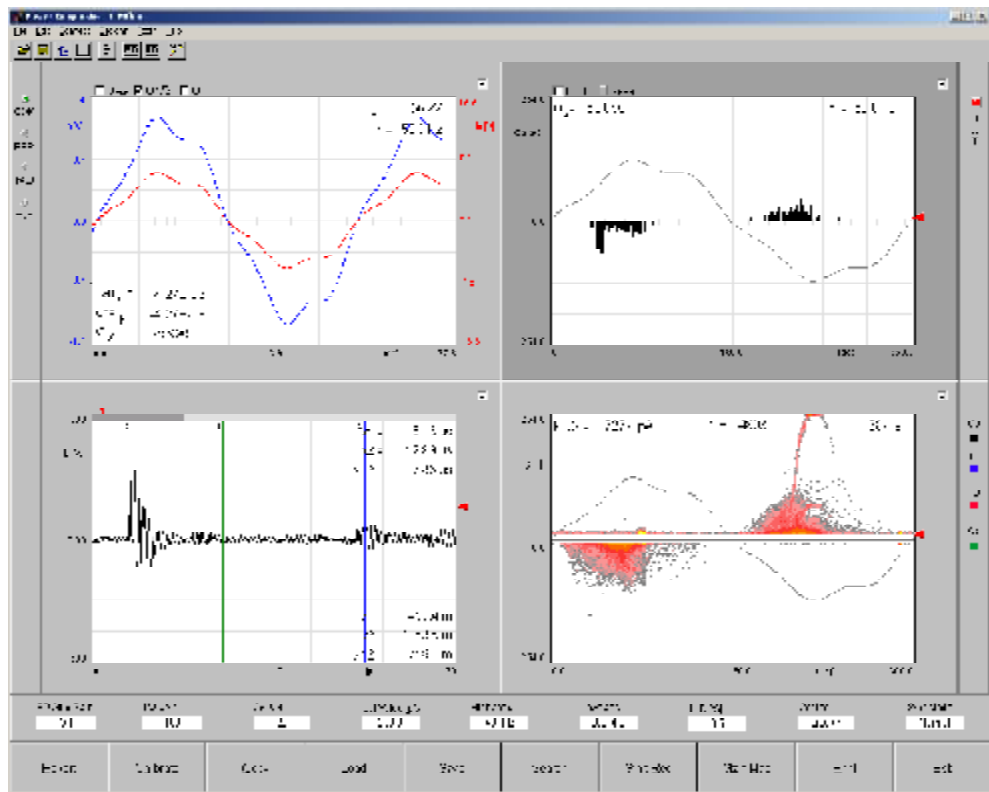
ICMflex & HV filter



On-site cable testing



TD measurement on motor bars



ICMflex software with TD Option

Option TD

The tan delta analyzer uses an unbalanced bridge formed by internal shunt capacitors, the reference capacitor and the device under test. Here, the ICMflex software shows $\tan\delta$, PF, capacitance, voltage, and frequency.

(above) based on the data received via Bluetooth. Placing the quadrupole and acquisition unit on high voltage potential greatly improves the sensitivity and avoids any noise pickup on signal cables.

Option PD

With the option PD the ICMflex software offers a meter display according to IEC60270 and an oscilloscopic display of the partial discharge activity as well as a colored $j-q-n$ pattern

Option PDL

The partial discharge location option uses high speed (100 Msample) sampling of the PD pulses traveling the cable. Along with the analog bandwidth of 20 MHz this enables precise location and mapping of the discharge activity along the cable.

Using wireless Bluetooth or fiber optic technology the ICMflex $\tan\delta$ and partial discharge analyzer family increases operator's safety and greatly simplifies off-line testing and analysis of distribution class cables and rotating machine stator windings.

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TDAcompact

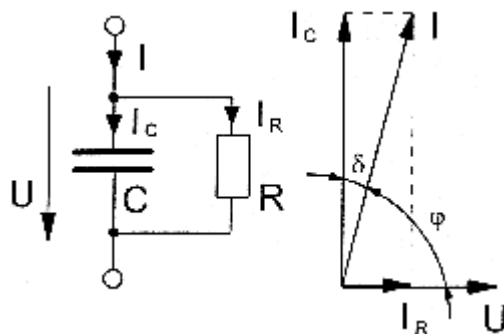


The TDAcompact is a portable capacitance and $\tan\delta$ analyzer. The focus of the instrument's application is on the analysis of the epoxy-mica insulation of rotating machines. Besides this, the unit is applicable for oil-paper insulation systems and especially for mass-impregnated cables.

Analyzing the dissipation factor ($\tan\delta$) is a traditional method to assess the condition of an insulation system. With the analysis of the dissipation factor, emphasis is more put on the overall health of the insulation system, whereas with partial discharge analysis, the focus is on individual defects producing discharge activity. Therefore, the application of $\tan\delta$ measurements concentrates on insulation systems, which are relatively stable against partial discharge.

Most prominently, the health of an epoxy-mica insulation of a rotating machine can be assessed using a $\tan\delta$ analyzer. Especially, the presence of humidity within the winding, the surface contamination of field grading elements, or the polarization losses of improperly cured resin, can be detected. Thus, the $\tan\delta$ analysis is still a good complement to the partial discharge testing.

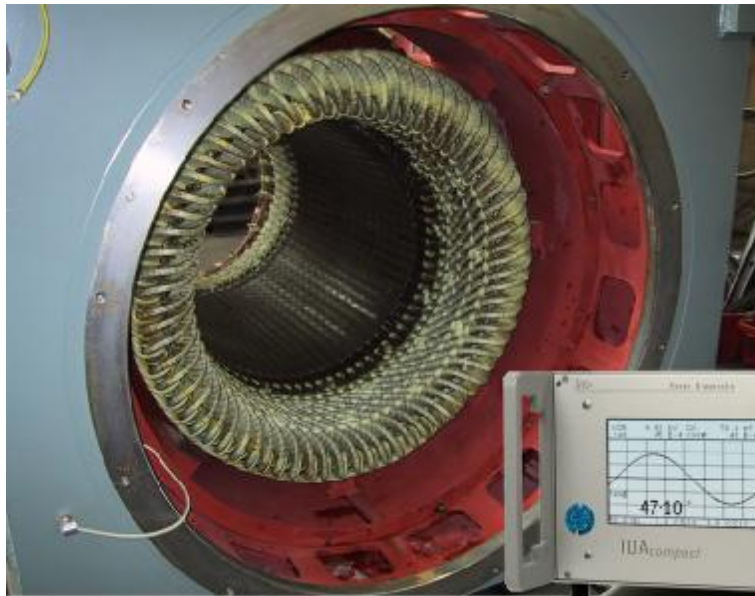
Portable and accurate $\tan\delta$ analysis



Dissipation Factor

Principle of Operation

The TDAcompact simultaneously samples the ac current drawn by the device under test and the current drawn by a reference capacitor. Subsequently, the two current traces are evaluated and the capacitance, the $\tan\delta$, and the level of the high voltage are calculated. The unit continuously displays and refreshes these results.



Therefore, the instrument does not require any user interaction as with the traditional Schering Bridge, nor does the refresh of the display take that long as with automatic adjusting bridge-type analyzers. The basic resolution of the $\tan\delta$ measurement is 10^{-4} , which fulfills the requirements for rotating machine testing as well as for testing on mass-impregnated cables.

Stand-alone Instrument

The TDAcompact is designed as a stand-alone instrument. In its basic configuration, it comes with precision shunts to measure the two currents. Optionally, the unit can be supplied with a normal capacitor. Generally, the TDAcompact is with digital fiber-optic links to the precision

shunts, which allow operation on any potential including the high voltage connection of the device under test. The measuring frequency can vary between 20 and 500 Hz or is fixed to 0.1 Hz (VLF). Upon request, Power Diagnostix can supply complete portable $\tan\delta$ testers including the high voltage transformer.

Modular Concept

Besides the stand-alone field test application of the TDAcompact, the instrument can also become a part of a larger and automated test system. Using the software HVpilot, the instrument will be read according to a pre-programmed test sequence. Besides $\tan\delta$ measurements, such automated test systems further include partial discharge measurements and so-called step tests.

Offering adequate resolution and accuracy as well as an unmatched portability, the TDAcompact is an excellent choice for field-type dissipation factor measurements. Additionally, the TDAcompact can be used as a module of a flexible automated test system.

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HVcompact



The HVcompact is a high voltage meter with an auto-ranging oscilloscope display of the voltage waveform. The unit displays \hat{U} , $\hat{U}/\sqrt{2}$, U_{rms} , frequency, and the crest factor. To improve the readability, one selected measurement is displayed using larger characters. To protect test specimens, the unit offers a pre-settable voltage limit, which trips a relay output. The divider ratio is widely adjustable and is kept with a non-volatile memory.

Mostly, the HVcompact is used in case of modernization or upgrade of high voltage test sets. With conventional analog or digital panel meters, usually, solely the voltage is displayed. The HVcompact adds several helpful functions.

saturation or power frequency harmonics, for instance, are clearly identified with this display. The screen is automatically synchronized with the measured voltage and the amplitude deflection is controlled by an auto-range function.

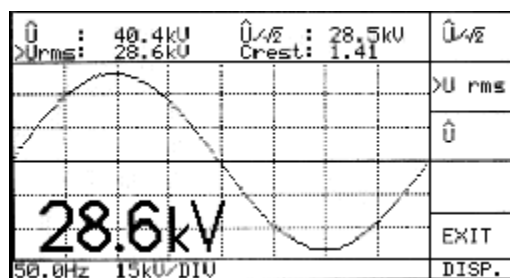
Oscilloscopic Display

The input voltage is sampled in high resolution and one cycle is displayed as an oscilloscopic trace. Any distortion of the high voltage due to transformer core

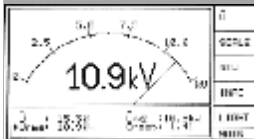
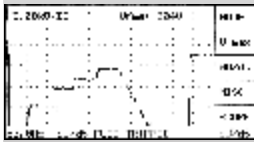
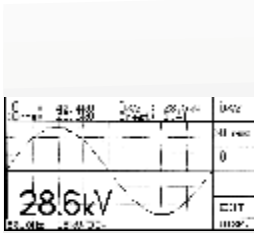
*All voltage information
at a glance*

Measurements

Usually, the instrument connects to capacitive or resistive divider. With larger high voltage transformers, the capacitance of the condenser bushing can be used. Within the menu of the HVcompact the divider ratio can be adjusted. It is kept with a non-volatile memory. The nominal input range of the HVcompact is $100 V_{rms}$. In order to cover correctly even strong harmonics, peak voltages of up to 200 V are accepted and sampled.



Scope display of the waveform



Using the sampled voltage, the instrument calculates based on the preset divider ratio the characteristic quantities of the high voltage signal. With the upper two lines of the display the peak voltage \hat{U} , the peak voltage divided by the square root of two $\hat{U}/\sqrt{2}$, and the effective voltage U_{rms} is shown. Additionally, the crest factor is calculated and displayed. With the bottom line of the display, the frequency of the captured voltage signal is shown. This bottom line further shows the scaling of the Y-axis grid of the oscilloscopic display. One selected value is displayed using larger characters for improved readability.

Safety Features

A voltage limit can be set with the instrument in order to avoid that a test specimen is stressed above its allowable voltage. In case the voltage then exceeds this limit, a relay is tripped. This relay can be used to block the 'UP' button of the control circuit or to disconnect the main circuit breaker. Additionally, the instrument detects incipient breakdown or flashover. Therefore, a maximum permissible voltage change per second (dU/dt) can be set.

Giving an instant display of all relevant parameters of a high voltage signal including an oscilloscope trace makes the HVcompact an ideal upgrade for high voltage test rooms. Additionally, the HVcompact detects incipient breakdown and keeps a record of the voltage history.

Each individual cycle of the high voltage signal is analyzed. Especially with long-term voltage endurance tests, this feature can minimize the thermal destruction of the breakdown channel and, thus, improves the analysis of the defect.

Optional REC OUT

The HVcompact is available with an optional recorder output. In case, a connector carries a re-converted analog (DC) signal of 0-10 V, which corresponds to the high voltage signal. This signal can be fed to a paper recorder, for instance. A screw terminal carries the optional relay output signals for voltage limit and breakdown detection.

Calibration

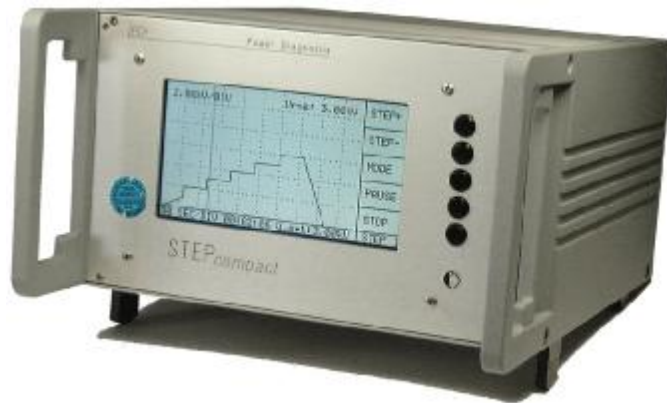
0606000
DKD-K-31101
06-06



By end of 2003, Power Diagnostix received the accreditation as calibration laboratory within the German Calibration Service (Deutscher Kalibrierdienst, DKD). The audit was held by 'Physikalisch Technische Bundesanstalt' PTB, the German authority of standards. Power Diagnostix accreditation is filed under DKD-K-31101.

In 2006, Power Diagnostix extended the accreditation by AC high-voltages up to 100 kV. On order the HVcompact can be calibrated on site together with its divider impedance.

STEPcompact



Increasing the high voltage stepwise is a task that is often required during type testing and production testing of high voltage products. The STEPcompact is an instrument to automate such step tests. The unit combines the control function with the measurement capabilities of a high voltage meter. As a stand-alone instrument, the STEPcompact can be easily moved between different high voltage test sets.

The STEPcompact measures the voltage signal derived from a capacitive or resistive divider. Using a fiber optic transmission, the UP and DOWN relay contacts of the voltage regulator are actuated to adjust the high voltage according to the programmed test sequence.

Using the five menu-driven control buttons, up to 35 different test sequences can be programmed and stored in a non-volatile memory. A test

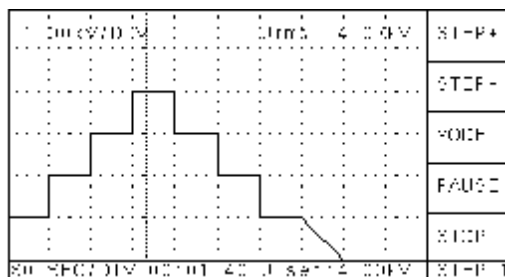
Safety and automation for step test sequences

Features

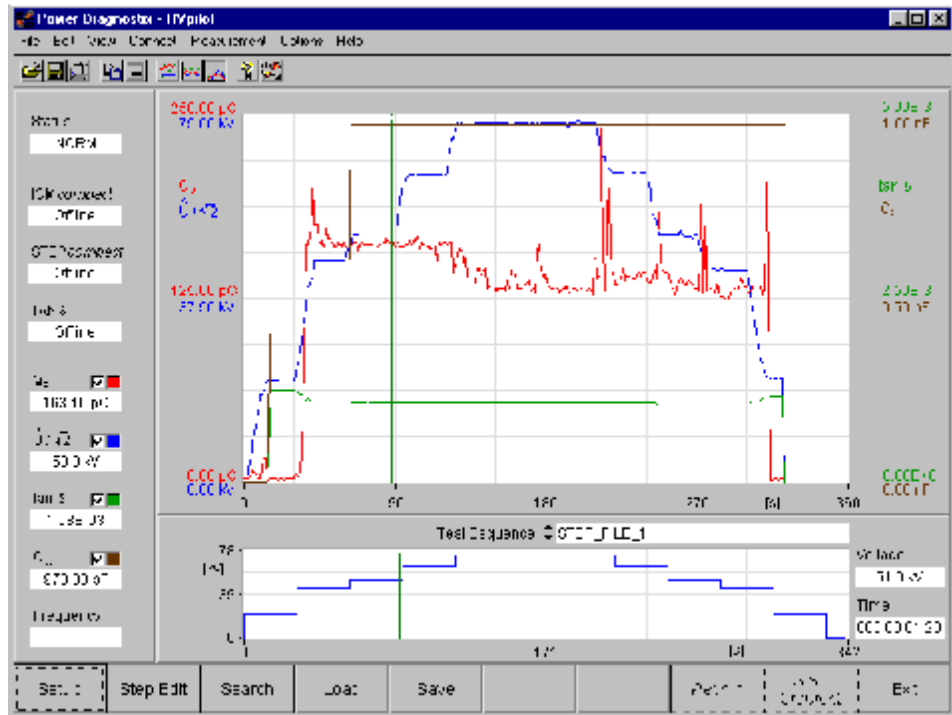
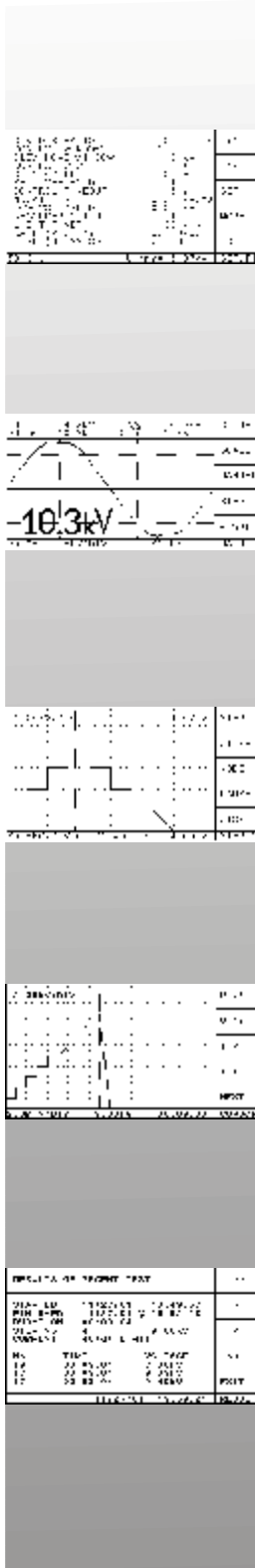
Similar to the HVcompact, the instrument calculates and displays the characteristics of the captured high voltage signal such as \hat{U} , $\hat{U}/\sqrt{2}$, U_{rms} , frequency, and the crest factor. The unit accepts a nominal input voltage of 100 V_{rms}. In order to correctly acquire even excessively distorted high voltage signals, the STEPcompact samples up to 200 V peak signals.

sequence consists of steps and ramps in any order. Besides the automatic mode, a manual mode can be used to set a specific voltage and keep it over time. In factory environments with strongly varying load situations, this function can be very helpful to maintain a stable high voltage level with long-term tests.

Up to seven configurations can be stored in the non-volatile memory in order to adapt the instrument to the properties of different high voltage test sets. Besides the divider ratio, a configuration setup contains settings such as the control cycle or the control window to tune the instrument to the properties of the high voltage test set.



Running step test sequence



HVpilot software

In the standard configuration, the STEPcompact comes with a self-contained relay box that is remotely controlled via a fiber optic cable. Alternatively, a direct connection to the HVcontrol, Power Diagnostix standard control unit for high voltage test sets, can be provided.

To ensure a safe unattended processing of a step test, the STEPcompact offers several safety features. Incipient breakdown is detected by monitoring the change of the voltage (dU/dt). Further, timeout limits can be set. The instrument keeps a record of the recent test to validate its successful completion or to indicate the point of breakdown or cancellation.

HVpilot Software

The HVpilot software allows the complete supervision of a high voltage test sequence. Using a serial interface, the software connects to the STEPcompact for the voltage control and measurement. Further, the HVpilot software offers convenient programming and editing of the test sequences. Additionally, this software can connect to the ICMcompact to read the partial discharge level and to the TDAcompact to read the $\tan\delta$ as well as the capacitance of the device under test. An export function allows to save the acquired data in file formats for MS-Excel and MS-Word.

Offering complete measurement of high voltage signals plus flexible programming of step test sequences makes the STEPcompact an ideal and cost-effective solution to automate high voltage test sets. The optional software HVpilot offers convenient programming and reporting.

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HVcontrol



The HVcontrol unit combines all standard functions required to manually operate a high voltage transformer. It includes a safety contact loop, the measurement of primary and secondary current, as well as of the primary voltage. User-settable limits for the primary and secondary current trip the main circuit breaker. The safety loop, as well as the emergency stop is hard-wired and equipped with forced contacts.

Due to its flexible design, the HVcontrol can be used on any high voltage test set. Especially, in case of the modernization of old test sets, the HVcontrol offers a multitude of improvements if compared with conventional relay based controls.

The HVcontrol comes in a 19"-subrack (3HU). This makes it an easy replacement of older controls having the same size. On its rear panel, the HVcontrol offers conveniently detachable screw terminals for the different controls and optional instruments.

The unit comes with rigid solid-state piezo push buttons. Each of these control buttons has an illuminated ring to indicate the state of the function controlled by this specific button. This allows an easy and intuitive operation of the HVcontrol.

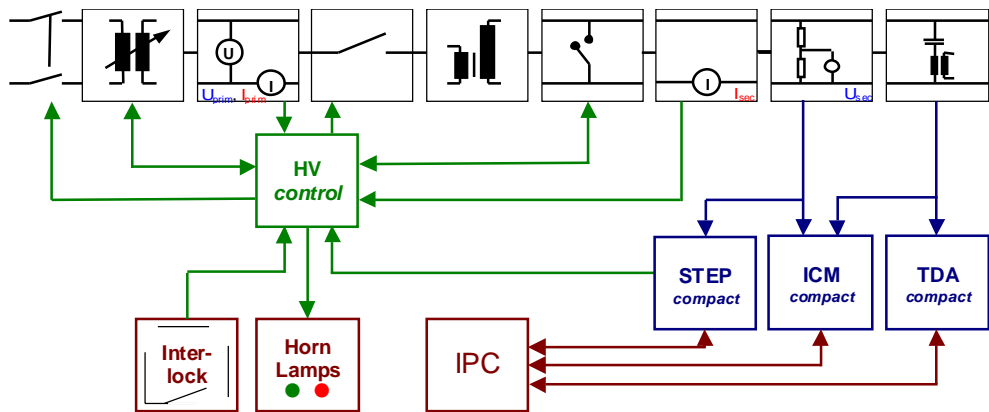
*Drop-in replacement
of old control units*



HVcontrol embedded in a control desk

Modular Concept

Besides a mere drop-in replacement of an old control, the HVcontrol can be combined with other test instruments of Power Diagnostix to build a fully automated acceptance test environment. On its rear panel, the HVcontrol is prepared to directly connect to the STEPcompact, Power Diagnostix instrument for the automation of test sequences (step test).



Block diagram for the connection of a HVcontrol

Further, the instrument can be combined with the ICMcompact for partial discharge testing and with the TDAcompact for $\tan\delta$ and capacitance measurements.

programming and editing of the test sequences. Additionally, this software can connect to the ICMcompact to read the partial discharge level and to the TDAcompact to read the $\tan\delta$ as well as the capacitance of the device under test.

Fully automated test systems

Power Diagnostix also provides industrial PC's to control the combination of instruments. Depending on the application and its requirements, the instruments can be mounted in desktop enclosures, 19" racks, or control desks fitted with 19" mounts.

HVpilot Software

The HVpilot software allows the complete supervision of a high voltage test sequence. Using a serial interface, the software connects to the STEPcompact for the voltage control and measurement. Further, the HVpilot software offers convenient



Control and measurement system

Easily replacing out-dated control units of high voltage test sets make the HVcontrol a good choice when modernizing high voltage test labs. Additionally, the HVcontrol is prepared to interface with the STEPcompact for automated high voltage tests.

FOsystem



Instruments

FOsystem - Fiber Optic Signal Transmission

The FOsystem is a complete set of instruments for convenient fiber optic transmission of different types of analog signals from a variety of sensors. The FOsystem allows easy implementation of fiber optic transmission to solve noise, safety, and signal quality issues in high-voltage measuring environments and other demanding conditions. The signal bandwidth covers DC up to 10 MHz.

Fiber Optics vs. Wiring

Harsh electromagnetic conditions prevalent in high-voltage and high-current laboratories seriously interfere with the use of conventionally wired measuring equipment. Fiber optic cables that are not prone to electromagnetic interference can replace even long BNC cables.

Applying fiber optic isolation with high impulse-current applications allows the ground potential to have dramatically transient changes without affecting the integrity of the signals captured and transmitted.



Fiber Optic Transmitter FOT1/5

System Components

The Power Diagnostix FOsystem comes in three basic variations, for each of three signal types:

- FOS1 for analog transmission of analog signals from DC up to 10 MHz
- FOS2 for digital transmission of analog signals from DC up to 20 kHz
- FOS3 for pulsed digital transmission of slowly changing signals such as temperatures.
- FOS4 for digital transmission of analog signals from DC up to 65 MS/s

All versions consist of transmission units, receiver units, and sturdy fiber optic cable.

The fiber optic transmitter modules (FOT) are small individual modules for installation at sensors or signal sources. The fiber optic receiver modules (FOR) are mounted side-by-side in a 19-inch or half 19-inch rack.

Operation

The output signal of the signal source or sensor (for example, voltage, dynamic pressure, current, or partial discharge) is fed to the input of the FOT. The transmitter then either modulates the infrared light emitted by the transmitter diode according to the value of the input signal (amplitude modulation, FOS1), or digitizes the signal and transmits a digital telegram. This optical signal is transmitted via the fiber

to the receiver, which converts it back to voltages for further processing.

The transmitter is installed in a cast-aluminum enclosure. The FOT is fitted with a NiMH-battery for a minimum operating time of twenty hours (FOT1 and 2), whereas the FOT3 offers up to two years of operation while sending a telegram every five seconds.



Acoustic sensor



Transmitter unit



Receiver (3 channels)



Temperature measurement (including receiver)

Type	Option	FOS1	FOS2	FOS3	FOS4
FOT1	Analog transmitter 0.2 Hz - 5 MHz (-3dB)	X			
FOT2	Digital transmitter 0 - 20 kHz (-3dB)		X		
FOT3A	Transmitter for temperature measurement			X	
FOT3B	Transmitter for voltage and current			X	
FOT4A	Digital transmitter up to 65 MS/s, (30 MHz bandwidth)				X
FOT/S2	Pressure measurement	X			
FOT/S3	Fixed DC coupling	X	X		X
FOT/S4	Switched DC coupling	X	X		
FOT/S6	Remote activation	X			X
FOT/S7	Special input range	X	X		X
FOT/S8	Pressure measurement (Kistler 6203 sensor)	X			
FOT/S9	Displacement measurement	X			
FOT/S10	Bandwidth 10 MHz	X			
FOT/S12	S12, ultrasonic measurement	X			X
DIV10	Pre-divider 1:10 (BNC-BNC)	X	X		X
DIV100	Pre-divider 1:100 (BNC-BNC)	X	X		X
DIV1000	Pre-divider 1:1000 (BNC-BNC)	X	X		X
FOR1	Receiver plugin 0.2 Hz - 5 MHz	X			
FOR2	Receiver plugin 0 - 20 kHz		X		
FOR3	Receiver plugin FOR3			X	
FOR4	Receiver plugin up to 65 MS/s, (30 MHz bandwidth)				X
FOR/E2	DC coupling, track/hold switch	X			
FOR/E3	DC coupling, adjust button	X			
FOR/E5	1.2" width, output on rear side	X	X		
FOR/E6	Bandwidth 10 MHz	X			
FOR/E7	Bandwidth limit 1 MHz, noise reduction	X			
FOR/E8	1-channel remote transmitter	X			
DR42	Desktop rack 1/2 19"	X	X	X	X
DR84	Desktop rack 19"	X	X	X	X

Conveniently providing robust fiber optic transmission of analog signals in high-voltage environments, the Power Diagnostix FOsystem solves signal integrity problems and safety issues found with severe electromagnetic conditions and long distances.

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FOSystem (FOS4)



The latest family member of Power Diagnostix' fiber optic transmission systems, FOS4 offers high speed data acquisition via fiber optic cables on multiple channels in parallel. The scalable system allows the acquisition of acoustic PD signals or other measurement signals under AC, DC, or impulse testing in laboratories as well as on site. The modular system accepts up to twelve optical channels and comes with high-speed controller card to communicate with a notebook. Besides this, the FOS4 system has additional signal output on the rear side and can be used as a digital isolated amplifier without the use of any software.

Application Example

PD Location by acoustic traveltime analysis (*ICMacoustic*)

The *ICMacoustic* system comprises of FOT4 transmitter units and FOR4D receiver units. Each channel acts as an independent transient recorder with its own storage and settable acquisition speed and storage depth. The sampling rate is 20Msample/sec. and, hence, suf-

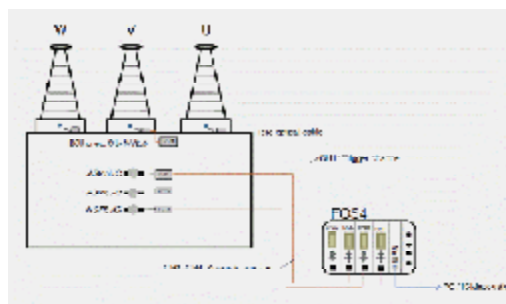
ficient to even acquire the pointing vector of the incoming acoustic wave, when using a two-dimensional three-sensor configuration.

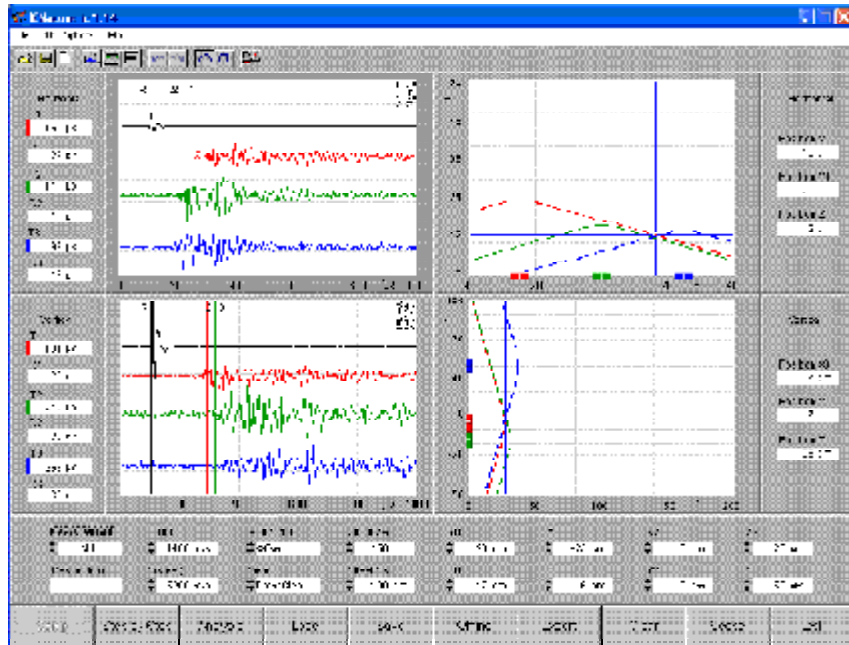
Acoustic location of PD on up to 12 channels in parallel

For PD location purposes the *ICMacoustic* software offers full control of the system.

Features:

- Sampling rate: 65 MS/s
- Up to 12 receiver units with independent optical channels
- Remote controlled via high speed USB port

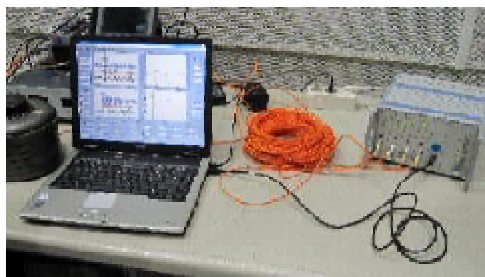
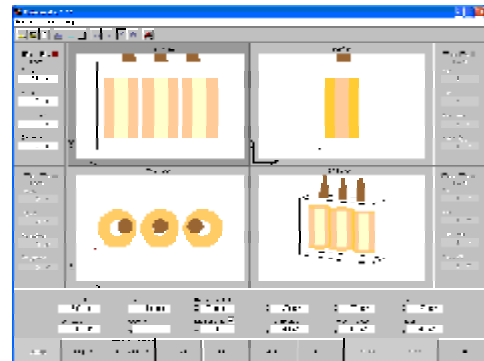




Measurement panel for horizontal and vertical triangulation

ICMacoustic Software

The ICMacoustic software offers full control of the FOS4 system including averaging and trigger logic. It is designed for the acoustic location of transformer partial discharge with the triangulation method. The basic idea is to reduce the location to a "flat problem". I. e., to horizontally position three sensors on a line to firstly get the hori-



ICMacoustic system

zontal position of the layer (see upper graph of the software's measurement panel, left). Here, the position of the sensors are entered and assigned to their channel. In a second step the sensors are placed on a vertical line at the found vertical position. In the lower graphs the sensor positions are entered accordingly.

With its versatile front end the FOS4 is a stand-alone fiber optical measurement equipment that allows to easily perform electrically isolated measurements with a variety of setting options. All parameters can be set either from the front side of the FOR4 device or via the ICMacoustic software.

ATTanalyzer



ATT analyzer - Acoustic Breakdown Location

Instruments

The Power Diagnostix ATTanalyzer is a simple and effective stand-alone tool to aid in commissioning tests of gas-insulated switchgear (GIS) systems and power transformers. The ATTanalyzer reduces delays in commissioning and maintenance by locating flaws in GIS systems and transformers acoustically.

Gas-insulated switchgear systems occasionally contain flaws that go unnoticed during installation or maintenance but that lead to immediate breakdown when high voltage is applied. These flaws can include floating particles, gaseous impurities, faulty insulator discs, sharp metal burrs, or other defects. If a gas-insulated switchgear system contains such a flaw when brought on-line, sparking and breakdown occurs at the flaw, forcing de-energization and repair. Without diagnostic aids, location of the flaw can lead to costly delays and unnecessary opening of unflawed gas chambers bearing the risk of causing new imperfections, while searching for the chamber containing the flaw.

Using the ATTanalyzer, the flaw can be located by mounting acoustic sensors to the outside of the GIS or transformer tank in several locations. When high voltage is applied to the GIS, if a breakdown occurs, the acoustic sensors pick up the disturbance and transmit a corresponding optical signal to the ATTanalyzer acquisition unit. The

ATTanalyzer then compares the relative travel times of the sound signals to determine which sensor is the closest to the flaw.

Following initial location of the break-

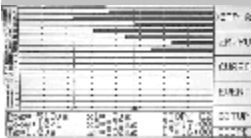


Fiber optic connectors of the ATTanalyzer

down's origin, the acoustic sensors can optionally be repositioned closer to the flaw to narrow the location further, to within a few centimeters. Comparing the resulting display with the display of the breakdown while using a hammer to trigger a similar pattern on the ATTanalyzer, further helps to narrow down the location of the flaw.



ATTanalyzer monitors a long-term test on GIS spacers and insulators (SIEMENS)



System Components

The ATTanalyzer consists of a compact central acquisition unit, acoustic sensors, and sturdy fiber optic cable to connect the sensors to the acquisition unit.

The stand-alone ATTanalyzer acquisition unit, mounted in a half-19-inch rack, receives and internally processes signals picked up by the sensors. The acoustic sensors for external mounting on the GIS system can be easily attached and removed for reuse. Up to sixteen sensors can be connected to the ATTanalyzer.

Fiber optic cables, up to 200 meters in length, provide galvanically isolated connection of the sensors to the ATTanalyzer acquisition unit.

Features

The ATTanalyzer's embedded LCD panel displays the relative travel times from the sensors as horizontal bars. Cursors and settings are manipulated through pushbuttons and on-screen menus.

The display screen also shows relevant quantities such as sampling rate, time between cursors, time and date stamp, etc.

Using simple menus, users can adjust the sampling rate of the acquisition unit appropriately depending on how widely or closely spaced the sensors are to each another. The ATTanalyzer features storage of up to sixteen GIS fault events with time and date stamps. Users can choose one of three operating modes:

AUTO This mode considers each trigger event. Thus, the instrument's memory contains the *most recent* 16 events.

NORM Using this mode, the unit changes to the STOP mode after 16 events captured. Therefore, the memory contains the *first* 16 events.

SINGLE This mode changes after each captured event into STOP mode. Changing manually back into RUN mode re-enables triggering.

Offering easy implementation and convenient data analysis, the Power Diagnostix ATTanalyzer aids in cost-efficient location and repair of gas-insulated switchgear and transformer defects during commissioning tests.

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GISmonitor



The *GISmonitor* builds on 15 years experience in online PD monitoring on rotating machines, transformers, cables, and especially GIS systems. It combines proven technology of the *ICMmonitor* with new processor technology and embedded hardware capabilities. The hardware core of the system has been optimized for parallel, real time PD acquisition on multiple channels. Any UHF signal can be detected and digitized within micro seconds. A separation of PD events from external disturbances or internal switching pulses is calculated in real time and therefore an effective PD and alarm detection is given.

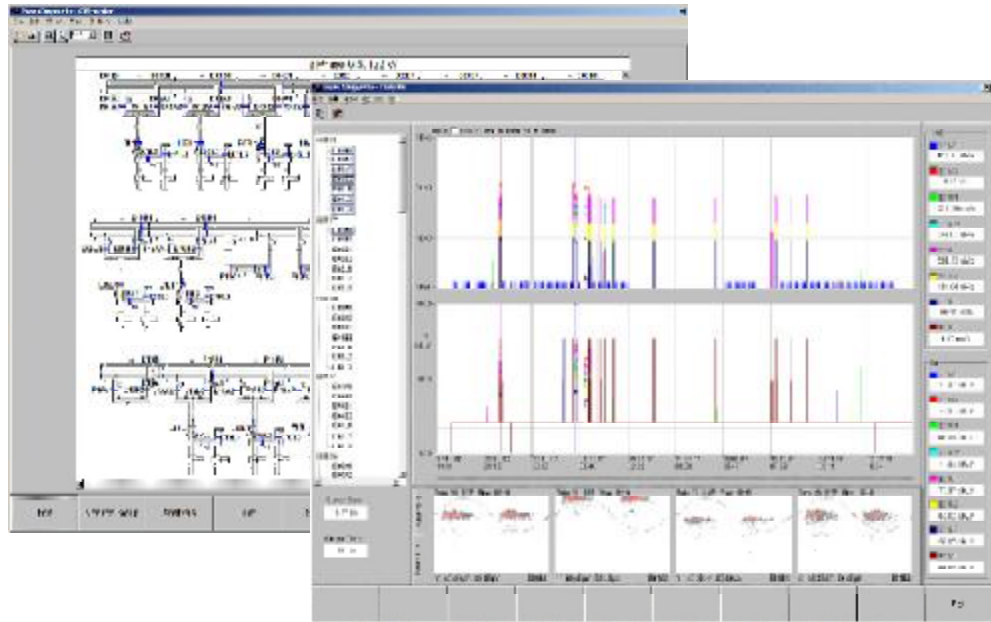
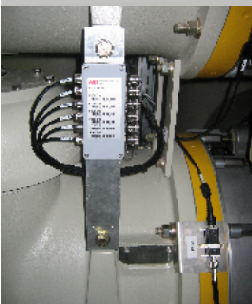
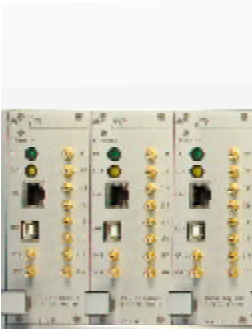
Each 8-channel acquisition plug-in operates fully stand alone, but can be combined with a virtually unlimited number of units, to monitor all PD sensors in one GIS PD monitoring system in parallel. A full 19" sub-rack carries 64 channels. A remote computer reads all data of the instruments via the high speed Intranet or USB bus. System redundancy is provided due to the local memory storage capacity on each acquisition unit. The *GISmonitor* indicates with on-board LED's internal states and alarm conditions.

Two main 19" racks are used to accommodate all instruments and the industrial PC. Each rack comes with a standard 19" frame, non-interruptible power supply, network switch and temperature controlled fans. With each installation multiple monitoring instruments are placed in one 19" rack. All cables from external are feed through the rear side into the rack. Alternatively a customized BNC patch board can be ordered.

Features

- Parallel UHF PD measurement on all channels
- Parallel reading of PD peak values, PD scope amplitudes, and PD patterns
- Separate gating input channel
- Automatic alarm detection system
- System redundancy
- Suitable for embedded and external retrofit UHF sensors
- Scalable system configuration
- Automatic noise suppression mode
- Network-based communication

The *GISmonitor* is designed to suit all currently available UHF sensors for GIS PD monitoring. This includes embedded and external retrofit UHF sensors. A special input protection unit (IPU2) blocks strong transients (VFT). The preprocessing unit (FCU or RPA6C) demodulates pulse UHF signals into a lower frequency band.



The user interface software panel of the GISmonitor monitoring system is installed on the local industrial PC and can be installed additionally on any remote computer for data evaluation and diagnosis. Using an administrative setup allows configuring the system and the embedded service program.

Software Features

- User friendly software panel including a customized GIS overview diagram indicating all sensors and its current activities
- Additional analysis and trending panel displaying Qp, NQS, scope, and pattern information of each channel at every time stamp
- Alarm event list indicating peak levels, PD patterns and trend information
- PD trending and PD pattern information of the full history
- Typical PD failure database
- Automatic data storage
- FTP access
- Interface to third party control systems, such as SCADA, DNP 3.0, MODBUS, IEC61850, and others.

Real time parallel PD acquisition on multiple channels

This service program takes care of reading data and alarm conditions from the instruments in a predefined time schedule. The service starts as soon as the computer has been turned on and, hence, a valid login on this machine is not mandatory to continue the data acquisition.

The GISmonitor is a scalable monitoring device for continuous monitoring of gas-insulated switchgear (GIS) using true parallel, real-time acquisition techniques.

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ICMseries Accessories: Preamplifiers



A few of the RPA series of preamplifiers

Preamplifiers serve to condition, filter, and amplify the partial discharge signal to be measured. Because the frequency range in which PD signals are measured is strongly dependent on the preamplifier used, proper selection of a preamplifier is an important part of noise mitigation and can have a strong effect on the appearance of the partial discharge pattern itself.

Power Diagnostix provides a complete line of modular preamplifiers for various testing applications. The most significant difference among the preamplifiers is the frequency range in which they detect partial discharge signals. Other features that distinguish one preamplifier from another are: options for transparency and on/off switching, unipolar vs. bipolar charge detection, and the possibility of galvanic isolation in the test setup.

All of the Power Diagnostix external signal conditioning modules and preamplifiers are remote supplied and remote controlled through a simple coaxial signal cable (RG58). This technique allows placement of these units close to the sensor or signal source. Furthermore, as these modules act as impedance converter and line driver, the weak signal source, such as voltage divider or coupling impedance, is not loaded by the cable capacitance or impedance.

This technique also provides enhanced over-voltage protection. All preamplifiers of the RPA series can drive a 50 Ω cable up to 50 m long.

The **RPA1** is the standard preamplifier for measurements in the low frequency range according to standards such as the IEC60270. The **RPA1B**, **RPA1C** and **RPA1D** are variations on the RPA1. **RPA1B** and **RPA1C** will put the signal through when the supply is turned off.



*The RPA1 preamplifier
(size approx 100 mm x 65 mm)*



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The **RPA1D** is suited to connect directly to ultra-sonic acoustic sensors. To simplify connection, the RPA1D provides selectable power supply for the sensor (15 V or 28 V DC).

The **RPA1L** and **RPA1H** are intended primarily for measurements on medium and high-voltage power cables using the *ICMcompact*.

The **RPA2** is primarily for measuring the PD signal spectra found with rotating machines, while the **RPA2B** is used with capacitive sensors to monitor cables and cable accessories at a higher sensitivity.

The **RPA3** module is well-suited for measuring PD signal spectra, detected by sensors and antennas installed with gas insulated switchgear (GIS).

The **RPA4** is a preamplifier set with fiber optic transmission, offering outstanding isolation properties.

The **RPA6** allows selecting one of three frequency ranges according to the particular application. The logarithmic RPA6 is mainly used with monitoring applications, and as a versatile preamplifier for noise gating. The **RPA6C** is an ultra-wide band version of the RPA6, covering 300 MHz to 2 GHz. This preamplifier is mainly used for GIS monitoring with the *ICMmonitor*.

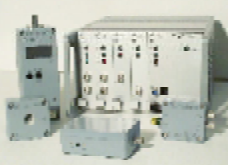
The **UHF1** offers an amplification of 27 dB in the range from 200 MHz to 1 GHz, and is suitable for boosting weak signals from GIS sensors.

The **HST1B** is an impedance converter for the measurement of voltages. The input impedance is as high as 10M Ω and ideal to measure the low-voltage wave from e.g. a voltage divider. The output is to be connected to the SYNC IN of the *ICMsystem*.

Reference table for commonly used Power Diagnostix preamplifiers

Type	Frequency range	Input impedance	Input sensitivity	Roll-off	Bipolar	Remarks
RPA1	40 kHz–800 kHz	10 k Ω / 50 pF	<200 μ V	40 dB/dec	ü	Standard preamplifier
RPA1D	40 kHz–800 kHz	10 k Ω / 50 pF	<200 μ V	40 dB/dec	ü	With built-in sensor supply
RPA1E	40 kHz–800 kHz	10 k Ω / 50 pF	<200 μ V	40 dB/dec	ü	0/20 dB attenuation
RPA1F	40 kHz–800 kHz	10 k Ω / 50 pF	<200 μ V	40 dB/dec	ü	For the <i>AICompact</i> only
RPA1G	40 kHz–800 kHz	10 k Ω / 50 pF	<200 μ V	40 dB/dec	ü	Like RPA1D but switchable
RPA1H	40 kHz–20 MHz	1 k Ω / 5 0pF	<400 μ V	40 dB/dec	ü	Oil/paper cable, DSO
RPA1L	40 kHz–20 MHz	1 k Ω / 5 0pF	<200 μ V	40 dB/dec	ü	Cable, DSO
RPA2	2 MHz–20 MHz	50 Ω / 5 0pF	<800 μ V	40 dB/dec		Rotating machines
RPA2B	2 MHz–20 MHz	50 Ω / 5 0pF	<200 μ V	40 dB/dec		Cable sensors
RPA3	200 MHz–1 GHz	50 Ω / 5 0pF	<300 μ V	40 dB/dec		GIS sensors
RPA3D	50 MHz–400 MHz	50 Ω / 5 0pF	<300 μ V	40 dB/dec		Nearfield detection
RPA3E	20 MHz–200 MHz	50 Ω / 5 0pF	<300 μ V	40 dB/dec		Nearfield detection
RPA4	40 kHz–800 kHz	10 k Ω / 50 pF	<200 μ V	40 dB/dec	ü	Fiber optic isolation
RPA6	40 kHz–800 kHz 2 MHz–20 MHz 200 MHz–500 MHz	10 k Ω / 50 pF 50 Ω / 5 0pF 50 Ω / 5 0pF	<200 μ V	40 dB/dec		For gating, selectable frequency range, logarithmic output
RPA6C	300 MHz–2 GHz	50 Ω / 5 0pF	<200 μ V	40 dB/dec		Logarithmic output
UHF1	200 MHz–1 GHz	50 Ω / 5 0pF	--	--		GIS, sensors
UHF2	300 MHz–2 GHz	50 Ω / 5 0pF	--	--		GIS, sensors
HST1B	20 Hz–400 Hz	10 M Ω / 2 0 0pF	--	--	ü	<i>ICMsystem</i> , SYNC IN

The versatility of the Power Diagnostix line of PD detection equipment is due in large part to the range of accessories available for the *ICMseries* instruments. Each *ICMseries* data acquisition unit can be combined with different accessories to suit specific applications.



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ICMseries Accessories: Quadrupoles & Isolation Transformer



When a quadrupole and a coupling capacitor are used together as the coupling device, high voltage is applied both to a test object and to the coupling capacitor in parallel with the test object. A quadrupole (sometimes called a measuring impedance) can then be placed in series with either the coupling capacitor or in series with the test object. Some quadrupoles also output a low-voltage copy of the applied high-voltage wave for synchronizing the PD detector. The three basic models of available Power Diagnostix quadrupoles are briefly described here.

CIL Quadrupole

The **CIL** quadrupoles consist of an inductor in parallel with a damping resistor. The inductor and resistor are calculated to form, together with a high-voltage coupling capacitor, a second order high pass filter. Therefore, matching the range of the CIL with the size of the coupling capacitor with which it will be used is important.



CIL/V Quadrupole

The **CIL/V** quadrupoles are similar to the CIL quadrupoles but also contain a capacitor acting as a voltage divider together with the high voltage coupling capacitor. This provides a low-voltage copy of the applied high-voltage wave that can be used through a HST to synchronize the PD detector and monitor the quality of the applied high-voltage wave.

CIT Quadrupole

The **CIT** coupling units are transformer type units, where a preamplifier's input resistance functions as the required damping resistor. CIT units offer a higher sensitivity than the CIL coupling units. Furthermore, CIT units are available for bridged configurations to connect to two similar test objects as well.



CIL/V Quadrupole

Optionally, the quadrupoles with built-in divider capacitor for voltage measurement can be supplied with a rotary switch to select the divider capacitor. Especially, when connected to the measurement tap of transformer bushings, the selectable capacitors expand the applicable voltage range.



Reference table of standard
Power Diagnostix quadrupoles

Type	Transformer Type	Voltage Range at 50Hz and C _c max.	Coupling Capacitor Range	AC Current Range	Isolated Input	Measurement at HV Cables	50 Ohm Matched	Opt. Balanced Mode (Two Bridged Inputs)	Voltage Divider Capacitor (to be specified)
CIL3M		400 kV	200pF – 800pF	100 mA					All CIL and CIT are available with one or two (switchable) built-in divider capacitors to provide a voltage output signal, marked by 'V'.
CIL4L		125 kV	600pF – 2.5nF	100 mA					
CIL4M		500 kV	600pF – 2.5nF	400 mA					
CIL4		1000 kV	600pF – 3.5nF	1.1 A					
CIL5L		125 kV	2nF – 9nF	350 mA					
CIL5M		250 kV	2nF – 9nF	700 mA					
CIL5		1000 kV	2nF – 12nF	3.8 A					
CIL6M		125 kV	6nF – 35nF	1.4 A					
CIT4M	✓	1000 kV	600pF – 2.5nF	800 mA	✓	✓		✓	
CITS4M	✓	1000 kV	600pF – 2.5nF	800 mA	✓	✓	✓		
CIT4	✓	1000 kV	600pF – 3.5nF	1.1 A	✓				
CIT5M	✓	500 kV	2nF – 9nF	1.4 A	✓	✓		✓	
CITS5M	✓	500 kV	2nF – 9nF	1.4 A	✓	✓	✓		
CIT5	✓	1000 kV	2nF – 12nF	3.8 A	✓				
CIT6M	✓	180 kV	6nF – 35nF	2.0 A	✓	✓		✓	
CITS6M	✓	180 kV	6nF – 35nF	2.0 A	✓	✓	✓		

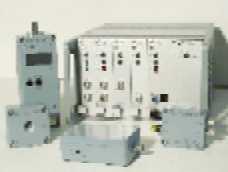
IT Isolation Transformer

The IT-series allows the isolation of 250 volts between input and output permanently. Its high frequency behavior is optimized for 50Ω-systems and the use with a multiplexer and RPA2 or RPA2B type of preamplifier. An extra voltage output 'V' with the 50/60Hz fundamental frequency is available on request.



Type	Max. AC Current	Max. Voltage (< 1 minute)	-6dB LF Cut-Off	-3dB LF Cut-Off	-3dB HF Cut-Off	-6dB HF Cut-Off	Input Connector
IT2	500mA	10kV _{AC}	200kHz	350kHz	>30MHz	>50MHz	BNC
IT3B	1000mA	500V _{AC}	100kHz	200kHz	>30MHz	>50MHz	BNC
IT4B	1000mA	500V _{AC}	100kHz	200kHz	>30MHz	>50MHz	Banana

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The versatility of the Power Diagnostix line of PD detection equipment is due in large part to the range of accessories available for the ICMseries instruments. Each ICMseries data acquisition unit can be combined with different accessories to suit specific applications.

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ICMseries Accessories: Coupling Devices & Filters



The Power Diagnostix line of coupling devices includes quadrupoles, current transformers, and coupling capacitors to adapt Power Diagnostix PD detectors to different measurement tasks. The coupling device in a PD measuring circuit provides the means of sensing the partial discharge pulse and sending it as a voltage signal to a preamplifier for conditioning.

The coupling device can be a capacitor and a quadrupole, a capacitor and a current transformer, or a current transformer alone. The standard capacitor for $\tan\delta$ measurements, such as the SC30, consists of a capacitor and a built-in shunt capacitor, only. Additionally, combined units for $\tan\delta$ and partial discharge measurements are available.

Coupling Capacitors

Power Diagnostix standard coupling capacitors are mounted on sturdy cast aluminum enclosures and can be used for on-line and off-line measurements on rotating machines as well as for a variety of smaller test setups. A wider range of coupling capacitors and capacitor assemblies complete with quadrupoles and preamplifiers is available on request. The table below lists some standard models of coupling capacitors provided by Power Diagnostix, along with their built-in circuits, if present.



Type	channel	spark gap	IN	OUT
CTB1A	3x	350V	BNC	BNC
CTB2A	4x	350V	BNC	BNC
CTB2C	4x	350V	TNC	BNC

Coupler termination box

Type	Capacitance	Nom. Voltage	Built-in Quadrupole	Built-in Voltage Divider	Built-in RF CT	max. Height [mm]
CC14B	220 pF	14 kV	ü	ü		190
CC20A	145 pF	21 kV			ü	300
CC20B	145 pF	21 kV	ü	ü		300
CC25A	1 nF	25 kV			ü	300
CC25B	1 nF	25 kV	ü	ü		300
CC25B/V	1 nF	25 kV	ü	ü		300
CC25C/V	1 nF	25 kV	ü	ü	ü	300
CC35B	145 pF	35 kV	ü	ü		310
CC35B/V	145 pF	35 kV	ü	ü		310
CC50B/V	500 pF	50 kV	ü	ü		500
CC50C/V	500 pF	50 kV	ü	ü	ü	500
CC100B	1 nF	100 kV	ü	ü		695
CC100B/V	1 nF	100 kV	ü	ü		695
CC150B/V	1 nF	150 kV	ü	ü		1210
CC200B/V	0.5nF	200 kV	ü	ü		1300

Standard coupling capacitors and supplementary circuits



3PI 2/20 Filter



PI 20/5 Filter



T70/100



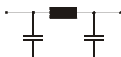
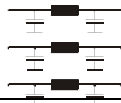
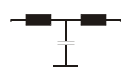
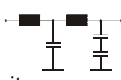
TCC50 Filter & Coupler

Filter

Partial discharge measurements are conducted in frequency ranges, which are partly covered by radio transmission. Further, impulse noise interference hamper sensitive measurements. Besides using small filters in the acquisition chain, power filters allow removing such disturbance from the high voltage supply. Power Diagnostix offer a range of different high voltage filters. Standard filters are available for induced voltage testing on large power transformers. Here, the rated voltage is 70 kV at a permanent current of 60 A (short duration: 100 A).



HV Filter T70/60

Type	Name	U _N	I _N	Size (WxHxD) cm
π -Filter 	PI 1/120	1 kV	120 A	
	PI 20/5	20 kV	5 A	50x47x35
3x π -Filter 	3PI 1.5/50	1.5 kV	50 A	40x17x46
	3PI 1/20	1 kV	20 A	40x17x46
	3PI 2/20	2.2 kV	20 A	40x17x46
T-Filter 	T 70/60	70 kV	60 A	50x100x45
	T 85/60	85 kV	60 A	50x100x45
	T 100/100	100 kV	100 A	50x100x45
T-Filter  ind. coupling capacitor	TCC 30/1	30 kV	1 A	50x67x35
	TCC 50/1	50 kV	1 A	50x80x35
	TCC 65/10	65 kV	10 A	50x100x45

The versatility of the Power Diagnostix line of PD detection equipment is due in large part to the range of accessories available for the ICMseries instruments. Each ICMseries data acquisition unit can be combined with different accessories to suit specific applications.

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ICMseries Accessories: Sensors and Miscellaneous



SFX1



SFX2/50



AS751

Ultrasonic PD Sensors

The AS751 and AS1501 are active sensors with very high sensitivity for measurements on GIS, transformer tanks, or cable joints. They come with a built-in 40 dB preamplifier and can be connected to the RPA1D, RPA1F, RPA1G or directly to the AIAcompact, ICMsystem, ICMcompact or ICMmonitor.

The SFX1 is suited to secure the acoustic sensors on a GIS. The magnetic sensor fixtures SFX2 are for temporarily mounting of the acoustic sensors on a transformer tank.

WS80 / 95 / 140 Window Sensor

External window sensors are used to conveniently equip older GIS with UHF monitoring. Power Diagnostix offers such window sensors of different sizes to fit the inspection windows of older GIS. Instead of embedded sensors, additionally, modified earthing switches can be used. In case of non-shielded support insulator disks a proven method is to apply ring antennas to capture the UHF signals at the flanges.



WS Window sensors in different sizes



EFS1 Sensor

EFS1 sensor

The external flange sensor EFS1 is a wide-band UHF antenna for PD detection on GIS and GIL. Since it is wrapped round the unshielded flange connection, the flange dimensions are required on order. With the N-connector it can be directly jointed with a UHF preamplifier like the UHF1, UHF2 or RPA6C.



AB1

AB1 Active Bridge Adapter

The active bridge adapter is an optional accessory that can be used in certain circumstances to “subtract” noise from the measurement setup.

The active bridge adapter AB1 serves to balance the signal picked up by two preamplifiers to reduce the common mode noise or disturbance. This method is applicable when two branches are available.

A mismatch of the signal strength can be adjusted with the AB1’s control knob. With the preamplifiers of the two branches connected to the “Pos” and “Neg” input of the AB1, and the output connected to the AMP IN of the PD detector, the control knob is used to minimize the common mode signal.

CTB1 Coupler Termination Box

The CTB1 provides protective grounding of the cabling coming from the coupling capacitors. An over voltage protection of the signal path is included and ensures safe working on live test specimen.



Foil sensor DFS

DFS Differential Foil Sensor

Besides the embedded coaxial sensor of cable accessories, external sensors can be applied to joints and terminations. Especially on cross-bonding joints differential foil sensors serve to capture partial discharge signals in elevated frequencies. Such foil sensors can be permanently installed for monitoring or temporary applied for survey type measurements.



CSC1

CSC1 Signal Combiner

The CSC1 allows to select or combine signals from 4 BNC-inputs to one BNC-output. The input and output impedance is thereby kept to 50Ω, even if one channel is selected or if the sum of all four channels is selected.

IPU1, IPU2 Input Protection Unit

The protection units are designed to avoid damage of spectrum analyzer input circuits or of preamplifier input stages under the presence of strong transient signals.



IPU1



IPU2

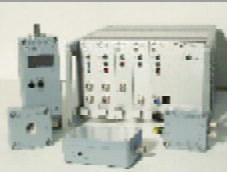


IPU4



CTB1

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ICMseries Accessories: Sensors and Miscellaneous



CT1 fixed current transformer



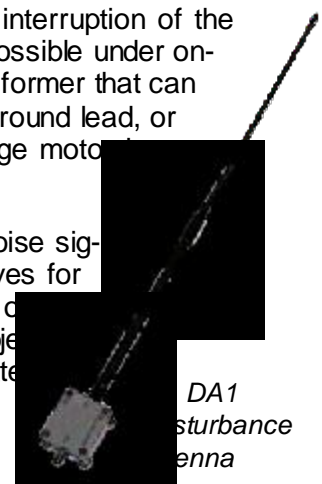
CT100 clamp-on current transformer

Current Transformers

When a current transformer is used instead of a quadrupole, the current transformer can be placed around a coupling capacitor terminal or around a part of the test object itself. A current transformer has the advantage of providing galvanic isolation between the ICMseries PD detector and the high voltage circuit. Power Diagnostix offers current transformers as separate modules or integrated with a coupling capacitor into a single unit.

The CTs are a low-impact PD sensor option since no interruption of the power connection is required. Such installation is even possible under on-line conditions, as the CT100 is a clamp-on current transformer that can be opened and clamped around a connecting cable, a ground lead, or even a feeding medium-voltage cable with a high-voltage motor installation.

The disturbance antenna DA1 can be used to pick up noise signals caused by local corona discharge, or AM radio waves for instance. It's magnetic holder allows a flexible placement on a transformer tank or to other metallic parts close to the object under test. The output signal can be used to trigger the gate input circuit of all PD acquisition or monitoring devices.



Type	Transfer ratio at 50 Ω	Primary window	Bandwidth at -3 dB	Bandwidth at -6 dB
CT1	1 : 10	15 mm	0.5 - 80 MHz	0.3 - 100 MHz
CT100	1 : 10	100 mm	2 - 25 MHz	1.2 - 40 MHz



BCU Bushing Coupler Unit

The Bushing Coupler Units are for permanent installation on power transformers. Together with a matching



BCU1D

bushing adapter they serve to make different signals available for measurement and monitoring. The bandwidth of the partial discharge signals extends to 20 MHz. The voltage signal of the built-in capacitive divider serves to synchronize the partial discharge acquisition and to measure the voltage. However, the excellent bandwidth of the voltage signal allows also transfer impedance measurements and $\tan\delta$ (power factor) measurements.

Transportation Case for the ICMseries Instruments

All instruments of the ICMseries can be delivered with a solid transport case with cut-out foam to carry one instrument and its accessories.



	Width	Height	Depth	Weight (empty)
Large	65 cm	27 cm	46 cm	7,5 kg
Small	49 cm	22 cm	38 cm	5,1 kg

BA Bushing Adapter

Type	Thread	Size	Connection	Size	Suitable for
BA2	inside	G4/4	fem ale	4 m m	Micafil, PORIB
BA3	outside	M45x2	fem ale	8 m m	
BA4 adapter	flange inside	-- M76x1.5	male	8 m m	
BA5	inside	M24	male	4 m m	HSP, ESKTFK 1050/245-A
BA6	outside	M38x1.5	male	4 m m	Micafil, WTF 420/1800 (1978)
BA7	outside	2 1/4" - 12UNF	fem ale	8 m m	Pcore, CSA standard, POC
BA8	inside	5/8" - 11UNC	--	3 m m	ABB, GOB
BA9	outside	M30x1.5	fem ale	4 m m	HSP
BA10	outside	M16x1.5	fem ale	4 m m	Trench, COT 650-2500
BA11	flange	--	fem ale	8 m m	GOA 650 / GOA 1050
BA12	outside	M30x2	fem ale	6 m m	NGK, R-D5350D-KEW
BA14	outside	1 1/16" - 12UN	fem ale	8 m m	TTI
BA15	outside	M30x2	fem ale	9 m m	NGK, R-C6200V-LN
BA17	outside	M30x2	fem ale	4 m m	ABB, GOB 1050-750-1100-0,6-B
BA18	flange	--	fem ale	8 m m	Mosizolyator, GMTA-90-110/2000
BA19	flange	--	fem ale	8 m m	Mosizolyator, GMTA-45-330/2500
BA20	outside	2 1/4" - 12UNF	fem ale	8 m m	Trench

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ICMseries Accessories: Calibrators



Power Diagnostix makes a range of calibration charge injectors suitable for use in calibrating partial discharge measurements. The appropriate choice of a calibration instrument depends on the range of typical charge values of the PDs being measured. Calibrators can also be used for time domain reflectometry in cables to determine cable length and location of joints.

Conformity to International Standards



By end of 2003, Power Diagnostix received the accreditation as calibration laboratory within the German Calibration Service (Deutscher Kalibrierdienst, DKD). The audit was held by 'Physikalisch Technische Bundesanstalt' PTB, the German authority of standards. Power Diagnostix accreditation is filed under DKD-K-31101.

New charge calibrators are shipped with the DKD calibration certificate to ensure the traceability to international standards. However, Power Diagnostix still offers the cost-effective factory calibration, if the formal traceability is not required.

Simple to Use

The calibrator is switched on with the pushbutton On/Off. Both amplitude (Range) and polarity (Pos/Neg) of the *single* charge pulse per cycle are displayed and can be adjusted by pressing of the two buttons. Each calibrator is also available supplying two pulses per cycle, as well as with double impulse output with adjustable interval.

The instrument automatically synchronizes to line frequency by a photo diode. In case of insufficient pick-up of power frequency light, the calibrator automatically selects the internal quartz oscillator (50Hz- and 60Hz-versions available).



CAL 1A



Available Calibrators

The standard calibration impulse generator CAL1A offers the charge range of 1/2/5/10/20/50/100 pC, while the CAL1B, mainly suitable for rotating machine testing, covers the range of 100/200/500pC/1/2/5/10nC.

Special signal sources are available for GIS measurements, such as the CAL2A: 0.5/1/2/5/10/20/50 pC, $t_r \leq 300ps$, $f_{3dB} \geq 1 GHz$, or with voltage output, the CAL2B: 0.5/1/2/5/10/20/50 V, $Z_L = 50 \Omega$, $t_r \leq 200ps$, $t_f = 100 ns$.

The Power Diagnostix line of calibration impulse generators is unique in that the charge pulse is generated by injecting a *variable* voltage step (correlated to an internal reference) via a *fixed* capacitor. This injection capacitor is relatively small, as the step voltage amounts up to 120 V for full range output. Therefore, the Power Diagnostix calibrators offer excellent impulse properties. Further, calculation of the correction factor is usually not necessary ($C_i \ll C_s$).

The standard line of Power Diagnostix calibration instruments is listed in the table below, along with their ranges and key features.

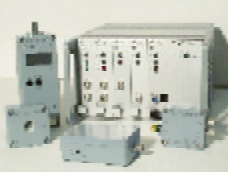


CAL1B

Calibration Impulse Generator	Range	Injection Capacitor (Ci)	50Hz or 60Hz light sync. IEC60270 compliant	2 pulses / cycle option	BNC connection	Usage
CAL1A	1, 2, 5, 10, 20, 50, 100pC	<1pF	✓	✓	✓	standard, lab use
CAL1B	100, 200, 500pC, 1, 2, 5, 10nC	<100pF	✓	✓	✓	see CAL1E & F
CAL1C	1, 2, 5, 10, 20, 50, 100pC* at 100pF	V (50Ω)	✓	✓	✓	c/w ext. capacitor
CAL1D	10, 20, 50, 100, 200, 500, 1000pC	<10pF	✓	✓	✓	standard, lab use
CAL1E	0.5, 1, 2, 5, 10, 20, 50nC	<500pF	✓	✓	✓	high level application, e.g. rotating machines, cable field tests
CAL1F	0.2, 0.5, 1, 2, 5, 10, 20nC	<200pF	✓	✓	✓	
CAL1G	0.02, 0.05, 0.1, 0.2, 0.5, 1, 2nC	<20pF	✓	✓	✓	transformer test
CAL1H	0.5, 1, 2, 5, 10, 20, 50pC* at 2pF	V (50Ω)	✓	✓	✓	GIS, live injection via stray cap.
CAL2A	0.5, 1, 2, 5, 10, 20, 50pC	<1pF	✓	✓	N	GIS & UHF
CAL2B	0.5, 1, 2, 5, 10, 20, 50V (into 50Ω)	V (50Ω)	✓	-	N	GIS & UHF
CAL2C	0.2, 0.5, 1, 2, 5, 10, 20V (into 50Ω)	V (50Ω)	✓	-	N	GIS & UHF
CAL3A	700kHz to 1.35MHz, 10μV to 10mV	V (50Ω)	✓		✓	RIV calibration
CAL3B	400kHz to 1.9MHz, 10μV to 10mV	V (50Ω)	✓		✓	RIV calibration

*with external high voltage capacitor

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Applications - Transformer



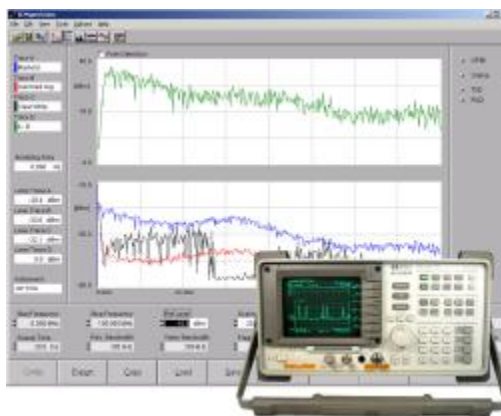
Partial discharge measurements on power and distribution class transformer are a proven tool to identify and locate defects within the insulation system of bushings, windings, or accessories. Besides PD acceptance test equipment for the testing labs in a factory Power Diagnostix offers a wide range of instruments for on-site on- and offline tests, and for monitoring.



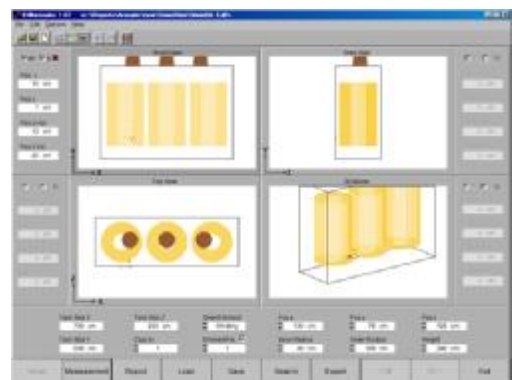
ICMsys8

The ICMsys8 greatly simplifies the PD acceptance tests on large power transformer. With its true parallel acquisition of the PD activity on eight channels, the overall testing period is substantially shortened. E.g. the cross coupling matrix for the different phases is done automatically while calibrating the test setup.

An advanced PD analysis system consists of an ICMsystem for PD pattern acquisition, a built-in or external spectrum analyzer for frequency domain analysis, a standard oscilloscope for the evaluation of the time domain signals, and an acoustic measurement system incl. triangulation software. The ICMspectrum software was developed to simplify the use of an external spectrum analyzer in conjunction with the PD measurement. Critical frequencies can easily be detected and filters can be set for in-depth analysis. The

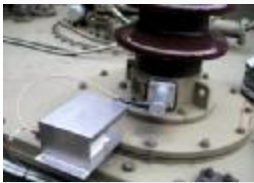


Remote SW with HP spectrum analyzer



ICMacoustic software, analysis panel

ICMacoustic software provides graphical and mathematical evaluation tools to precisely locate internal PD failures.



Bushing adapter



Transformer monitoring



Advanced PD test system



HV control room

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The *SPECcompact* comprises a spectrum analyzer and a partial discharge detector in one instrument. This allows PD measurements even in noisy environments like non-shielded test areas. Especially for testing distribution class transformer the *SPECcompact* allows measurements with a background noise below the demanded acceptance level.



SPECcompact

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.

PD Monitoring

Partial Discharge Monitoring has become increasingly important in the past few years. Besides other parameters like gas in oil analysis, temperatures, vibrations, or load conditions, etc., the PD trending information completes a full set of monitoring data of a transformer in the field. A series of standard bushing adapter (BA) is available to connect the measurement system to the test tap of a transformer bushing. For condition based maintenance, a portable instrument like the *ICMsystem* can be used on-site for temporary measurements. For continuous monitoring, an instrument such as the *SPECmonitor* or the

ICMmonitor can be considered. Acoustic sensors in combination with one of the mentioned PD instruments can be used to locate a PD fault more precisely.

Typical Packages

Set for Power transformer acceptance testing in a test bay:

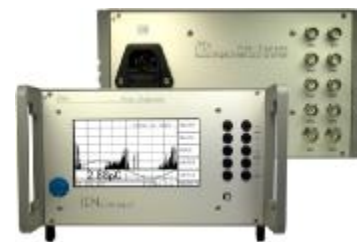
- 1 x *ICMsys8* (built-in modem opt.)
- 1 x GPIB interface
- 1 x Software *ICMsystem*
- 1 x Impulse calibrator CAL1D
- 9 x Preamplifier RPA1
- 8 x Quadropole CIL4M/V0 μ 5/2 μ 0
- 3 x Quadropole CIL5M/V4 μ 0

Set for distribution transformer Acceptance testing in a test bay:

- 1 x *ICMsys4* or *ICMcompact/MUX4*
- 1 x GPIB Interface (with *ICMsys4*)
- 1 x Software *ICMsystem*
- 1 x Impulse Calibrator CAL1D
- 4 x Preamplifier RPA1
- 3 x Coupling Capacitor CC100B/V

Optional items:

- RIV measurement
- Built in spectrum analyzer
- Scope with remote control software
- Acoustic Sensors and Preamplifier
- CT1 or CT100 for gating purposes
- HV Filter
- External spectrum analyzer



ICMcompact with multiplexer

Partial discharge testing on power transformer is an efficient tool to evaluate the condition of the complex insulation system. Power Diagnostix offers various optimized instruments and accessories for laboratory tests, field measurements, and continuous monitoring.

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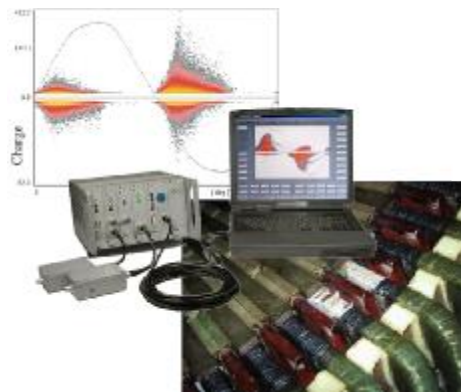
Applications - Rotating Machines



The typical epoxy-mica insulation system of rotating machines is a 'forgiving', i. e. a comparably stable insulation system. Due to this electrical stability, partial discharge activity acts as an indicator for a variety of defect mechanisms. Besides the mere electrical aging, further problems, such as contamination, vibration, or mechanical aging find their expression in the phase-resolved partial discharge pattern.

PD Measurements

Power Diagnostix offers various instruments for continuous monitoring, schedule-based routine testing and in-depth analysis of rotating machines. The instruments and their control software were continuously improved, based on more than ten years of testing numerous generators and motors.



PD activity acquired with the ICMsystem showing the non-symmetrical discharge pattern of a heavily deteriorated slot-exit field grading.

Permanently installed partial discharge couplers greatly simplify on-line testing

using the ICMsystem without any interruption or downtime. Continuous on-line monitoring of the discharge activity with a permanently installed ICMmonitor helps optimizing maintenance intervals and reducing costs, while improving the level of equipment dependability.

Tan Delta Measurements

The TDAcompact is a digital tan delta and power factor analyzer for off-line dielectric testing to assess the overall health of the insulation system. Its fiber optic signal transmission simplifies connection even on grounded equipment. The unit comes with reference capacitor and can be combined with any external high voltage source.





ICMmonitor on-site



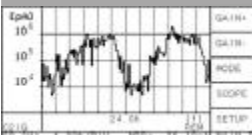
Stator coil



CT100



Coupling units CC20



ICMmonitor display

Partial Discharge Monitoring

Based on the stand-alone ICMmonitor unit connected to an individual machine, larger networks supervising a multitude of generators in combined-cycle thermal power plants or pump-storage hydro power plants have been realized. Such networks include full control of the local instrument via global Intranet access as well as visualization of the monitoring data in monitoring centers. The ICMmonitor software offers automated scanning, pattern acquisition, and analysis of the trending data. Additionally, the ICMpilot software serves to condense the information gathered from multiple plants on one overview screen, while having the full data history close at hand.

Large Motors

High voltage motors are key-components in refineries and the production of technical gasses according to the Linde process. Here, unplanned outages can cause immense losses. Further, such motors serve in thermal and nuclear power plants to run the (emer-

gency) cooling system, for example. Here, failure of a motor stator winding can cause critical subsequent damage. Installing specially suited coupling capacitors offers schedule-based measurements as well as continuous monitoring for the assessment of the insulation condition.



Couplers CC14B installed on a motor terminal box

Typical Packages

- Portable acquisition unit:
- 1x ICMsystem (opt. MUX8)
 - 1x ICMsystem software
 - 1x GPIB interface
 - 2x Preamplifier RPA1
 - 1x Preamplifier RPA2
 - 1x Voltage converter HST1B
 - 1x CT1 or CT100 (optional)
 - 1x Impulse calibrator CAL1B
 - Set of cables
 - Transport case

List of material per machine:

- 3x Coupling capacitors, type CC14B or CC20B
- 1x Mounting kit, MKB



ICMmonitor trending display

Partial discharge testing and monitoring on generators and large motors offers the assessment of the condition of the stator winding. This helps avoiding unplanned outages as well as scheduling efficient maintenance outages.

Applications - GIS / GIL



Besides factory partial discharge testing for quality assurance, field-testing becomes increasingly important for gas-insulated equipment. For the field applications UHF and acoustic detection methods complement the low frequency detection according to the IEC60270.

ICMcompact

The *ICMcompact* combines perfectly with small tank-type variable frequency test sets for the commissioning testing of gas-insulated substation equipment. Besides the flexible analog gating function, the *ICMcompact* comes with a TTL gating input to effectively suppress the switching impulses of the resonant test set.

For in-depth field analysis of partial discharge activity the *ICMsystem* can be combined with a spectrum analyzer. Power Diagnostix has written the special software *ICMspectrum* to utilize and control spectrum analyzers of different vendors for partial discharge analysis (HP 859xE, Agilent E4000, R&S FSL).



Field measurement set up

AIAcompact

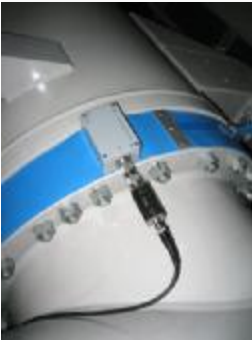
The main application of the *AIAcompact* is the acoustical detection of partial discharge in gas-insulated equipment. Conveniently, the unit provides the supply voltage of the different pre-amplifiers and the acoustic sensors. The instrument is lightweight and battery operated. Moreover, the *AIAcompact* allows conducting UHF measurements when connected to embedded or external UHF sensors. The *AIAcompact* automatically detects the pre-amplifier type and selects the appropriate operation mode.



ATT analyzer

ATT analyzer

The portable *ATT analyzer* is a simple and very effective tool to locate breakdown during the commissioning of GIS and GIL. Battery-operated acoustic sensors are externally mounted to the GIS and connected via fiber optic cable to the acquisition unit. In case of breakdown, the acoustic sensor transmits an optical signal to the *ATT analyzer*, when it has detected the sound wave. The *ATT analyzer* then displays the signals received from all sensors versus time like a logic analyzer. Following initial location of the breakdown's origin, the acoustic sensors can be repositioned closer to the flaw to further narrow down the location.



Ring sensor on GIS



GIS window sensor



Breakdown sensor



Preamplifier RPA6C



Acoustic sensor

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Partial Discharge Monitoring

The same sensors (external or internal) as used for commissioning can be used for continuous on-line monitoring of the partial discharge activity. Here, acquisition units equipped with built-in multiplexer scan the number of sensors, each directly connected to a small preprocessing amplifier unit (RPA6C). This preprocessing unit acts as a detector and converts the ultra-wide bandwidth signal into a low-frequency envelope signal, which is then conveniently transmitted via regular RG58 cable. The RG58 cable also provides the DC supply for the preamplifiers. Embedded modem units or TCP/IP interfaces offer remote access to a multitude of monitoring units via the Internet, an Intranet, or the telephone network.



Monitoring system

Typical Packages

Instruments for commissioning and service groups:

- AIAcompact
- ATTAnalyzer
- ICMsystem with spectrum analyzer or ICMcompact
- UHF preamplifier
- External retrofit UHF sensors
- Acoustic sensors
- UHF calibrator CAL2B



UHF impulse calibrator CAL2B

Example for a PD monitoring system on a 123 kV substation:

- 1 x Portable ICMmonitor, or
- 10 x ICMmonitor for permanent installation, 8 channel multiplexed;
- Option: built-in modem or TCP/IP
- 1 x Software ICMmonitor (GIS vers.)
- 1 x Remote computer
- 1 x Impulse calibrator CAL2B
- 80 x retrofit ring or window sensors
- 80 x preamplifier RPA6C
- 80 x Set of cables

Power Diagnostix range of instruments cover the entire needs of partial discharge testing on gas-insulated substation equipment from production testing and commissioning to maintenance and monitoring.

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Applications - Cables



Polyethylene is a 'non-forgiving' insulation system. Thus, close attention must be paid to partial discharge activity during factory testing, commissioning, and service. On-site measurement techniques have to cover the needs of an aging polymeric cable distribution net as well as an increasing application of polyethylene extra high voltage cables.

Extra High Voltage (EHV) Cables

Cables are generally factory-tested. The accessories of high voltage (HV) and extra high voltage (EHV) cables are usually also pre-tested. However, mechanical forces during the laying, hidden imperfections, and flaws caused by improper handling, for instance, require partial discharge commissioning tests. Ideally, the cable accessories of such transmission-class cables are equipped with embedded sensors. Power Diagnostix introduced this cost-effective principle in 1994 and numerous cable manufacturers have implemented it since then. The ICMsystem, especially if enhanced with the FOsystem for optical isolation, offers powerful tools for the

Medium Voltage Cables

As with HV and EHV cables, the ICMcompact is used for shop-floor production testing on medium voltage cables. During the past decade numerous cable manufacturers have changed to this instrument during the modernization of their test room.



PD fault location display



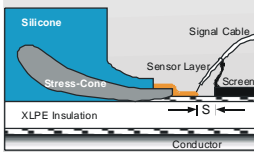
ICMsystem

analysis of the cable insulation system. Additionally, different pre-amplifiers and embedded or external spectrum analyzers complete the instrumentation.

A large population of service-aged medium voltage or distribution-class cables has reached their projected service life, as polymeric cables were increasingly introduced since the 1970ies. The ICMcompact is available in a ready-to-use package for field testing and partial discharge location with any external high voltage source. Especially the combination with very low frequency (VLF) sources and the combination with variable frequency resonant test sets provide lightweight and cost-effective solutions to keep the distribution grid reliable. The package includes a combination of T-filter and coupling unit to de-noise the HV source.



DFS for cable joints



Cable PD sensor



400 kV cable joints



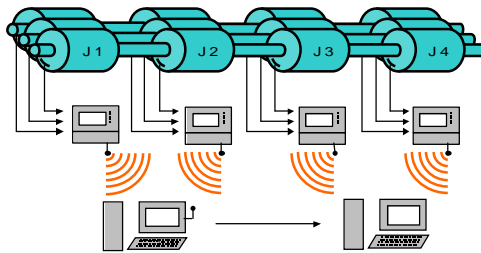
Cable monitoring



CT100 & RPA1

Special Sensors

Coupling capacitors, as used for factory testing and for off-line testing, are not applicable for on-line testing. Power Diagnostix offers several types of external sensors for PD measurements. The differential foil sensor (DFS) makes use of the stray capacitance of cross-bonding joints and offers comparable low-noise measurements at higher frequencies. The CT100 is a clamp-on HF current transformer that can be used to pick up partial discharge signals on ground leads and on cross-bonding connections. Further sensors including Rogowski coils can be tailor-made for any application. Power Diagnostix also assist with the design and implementation of embedded sensors.

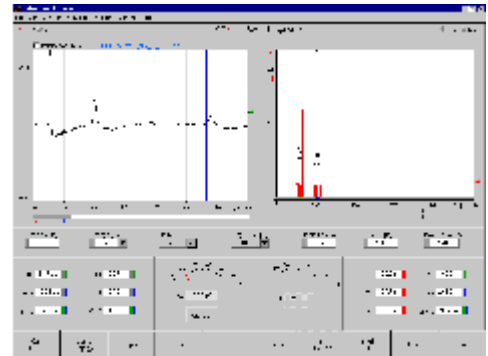


Monitoring system in a cable tunnel with WLAN interconnection

PD Monitoring

Generally, partial discharge monitoring can take care of any high voltage insulation system to detect incipient breakdown and on-going degradation. The defect mechanisms for cable accessories and for the cable itself differ due to different material properties, for example. When monitoring

EHV cables systems, a comparable long pre-warning time applies to EPR and EPDM accessories, while the cable insulation of a 400 kV XLPE cable, for instance, has a much shorter pre-warning time.



ICMcompact PD fault location software

Further, an installed monitoring system can be used of course also for the commissioning testing of the cable system. Besides using fiber optic TCP/IP interconnection, accessing the instruments via WLAN offers an effortless installation.

Typical Packages

Mobile PD fault location system consisting of:

- 1x Portable ICMcompact with built-in DSO board
- 1x Software ICMcompact with fault PD fault location
- 1x Coupling capacitor CC25D/V
- 1x Impulse calibrator CAL1B
- 1x Preamplifier RPA1H
- 1x Preamplifier RPA1
- 1x Set of cables

Combining the lightweight ICMcompact for partial discharge location with portable VLF high voltage sources or variable frequency resonant test sets offers cost-effective survey testing of a distribution grid.

Applications - Quality Control



Partial discharge test cabinet for stator coils of small induction motors

Partial discharge testing – well established for high voltage equipment – becomes increasingly important for insulation systems of a lower voltage level. Changing to switching power supply and to IGBT control of induction motors, for instance, raise demands and testing needs for the insulation system. The modular concept of Power Diagnostix' instruments allows offering customized solutions for automated and semi-automated testing.

Modular Concept

Different levels of automation can be provided depending on the testing needs. In case of full production testing a high level of automation and simple go/no go decision is needed,



whereas manual control offers a higher level of flexibility when testing samples or sample variants during development. Generally, such test arrangement consist of a test chamber with a built-in high

voltage transformer and instruments to control and measure voltage and partial discharge. The setup includes the safety interlock, automated grounding system, and over-current protection. Different levels of automation are offered combining the *HVcontrol*, the basic *HVcompact* for voltage measurement or the *STEPcompact* for programming voltage steps, ramps or more complex functions. Installed on an industrial PC, the *HVpilot* software then optionally controls these instruments and the *ICMcompact* for the PD signal and automatically prepares the test report. Additionally, Power Diagnostix designs special test fixtures, dual test chambers for increased performance, and customer specific software.

Alternatively, of course, such instruments can be used to modernize the control of an older high voltage transformer and its regulating transformer.



Control and measurement



TCU7,5



HV test room

Levels of Automation

Depending on the needs the instruments and controls can be compiled in different versions:

Level A:

Partial discharge test bench for sample testing consisting of a test chamber and manual voltage control equipped with an *ICMcompact* for PD measurement with voltage option or an *HVcompact* for voltage measurement.

Level B:

As level A, but with the *STEPcompact* instead of the *HVcompact* for automated voltage control.

Level C:

As above, but with an industrial PC and the *HVpilot* software for fully automated control and test report generation.

Level D:

Modernization of test rooms using *HVcontrol*, *HVcompact* or *STEPcompact*, and *ICMcompact*. Software control as with level C.

Typical Packages

Test setup (like level C) consisting of:

- 1 x *ICMcompact* with gating
- 1 x *STEPcompact*, 19" rack
- 1 x Test chamber 19", 18HU, incl. 10 kV voltage transformer, regulator, manual control buttons, horn, lamps, emergency stop, grounding system, coupling capacitor, ...
- 1 x Industrial PC
- 1 x Software *ICMcompact*
- 1 x Impulse calibrator CAL1A
- 1 x Pre-amplifier RPA1
- 1 x Set of cables



Typical test set

Type	Voltage	Power	Current	Connection	Height	Dimension WxHxD
TCU 3	0-230V	3kVA	16A _{max}	CEE 400/16A (L-N)	9HU	553 x 506 x 600 mm
TCU 7,5	0-230V	7,5kVA	34A _{max}	CEE 400/32A (L-N)	9HU	553 x 506 x 600 mm
TCU 10	0-230V	10kVA	48A _{max}	CEE 400/63A (L-N)	9HU	553 x 506 x 600 mm
TCU 10/2	0-400V	10kVA	25A _{max}	CEE 400/63A (L1-L2)	9HU	553 x 506 x 600 mm
TCU 15/2	0-400V	15kVA	38A _{max}	CEE 400/63A (L1-L2)	25HU	553 x 1218 x 600 mm

Partial discharge testing is increasingly applied for testing insulation systems of lower voltage levels. Power Diagnostix offers ready-to-use test chambers for easy and safe partial discharge testing on components and small samples.

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Services



Measurement in a transformer test bay

Power Diagnostix provides various services such as on-site measurements, commissioning tests, DKD calibration of instruments, installation of couplers and monitoring systems, as well as rental of test equipment. Additionally, Power Diagnostix acts as a consultant to analyze defect mechanism or to improve high voltage insulation systems, for instance.

Consulting

Power Diagnostix assists to analyze encountered defects, failure mechanism, and helps to improve insulation systems. Further, support is provided to implement monitoring systems and to integrate embedded partial discharge sensors into insulation systems. Additionally, Power Diagnostix offers interpretation service for partial discharge pattern acquired by local testing groups. Instruments equipped with modem allow also having Power Diagnostix dialing in for performing remote measurements and diagnosis.

discharge measurements. Such on-site measurements cover on-line and off-line diagnostics on rotating machines including large motors, partial discharge mapping on cable systems, survey-type measurements on gas-insulated substation equipment, and partial discharge acceptance testing and PD location on large transmission-class power transformers. All required instruments are provided, of course. VLF sources and smaller high voltage sources can be provided as well. However, rental of larger test sets needs to be subcontracted.



On-site measurements

On-site Measurements

Power Diagnostix engineers are available on short notice for on-site partial

Seminars and Training

Standard shop-floor partial discharge testing is a comparable easy task. How



Seminar held in Aachen 2006

ever, applying in-depth partial discharge diagnostics requires knowledge and experience. Here, Power Diagnostix assists with training sessions for testing and engineering personnel and with seminars for larger service groups. Besides the mere installation and usage of the instruments, emphasis is put on understanding the theoretical background of partial discharge pattern, defect mechanism, and the interpretation of measurement results.



Installing couplers on site

Installation Service

Especially for monitoring systems a complete installation service is offered. Typically, this installation of couplers and instruments include the calibration of the entire setup and the base-line measurement.

Rental of Equipment

Generally, Power Diagnostix testing equipment is available for rental or leasing, if budget constraints do not allow an investment, for instance.

DKD Calibration Service

Power Diagnostix operates a calibration laboratory, which has received the accreditation within the German Calibration Service DKD by 2003. The au-

dit was held by 'Physikalisch Technische Bundesanstalt' (PTB), the German authority of standards. Power Diagnostix' accreditation is filed under DKD-K-31101. The accreditation covers impulse charge (pC), voltages, and timing parameters. Since 2006 the accreditation includes also on-site calibration of voltages up to 100 kV_{AC}.

The DKD calibration service is of course also available for instruments and calibrator of other vendors. However, the cost-effective factory calibration applies only to instruments of Power Diagnostix make, if the full traceability of the DKD calibration is not needed.



DKD-calibration



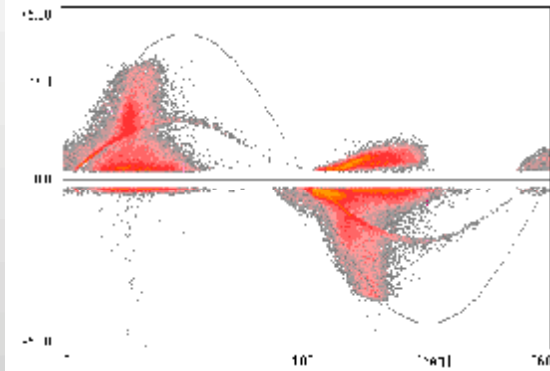
Factory-calibration



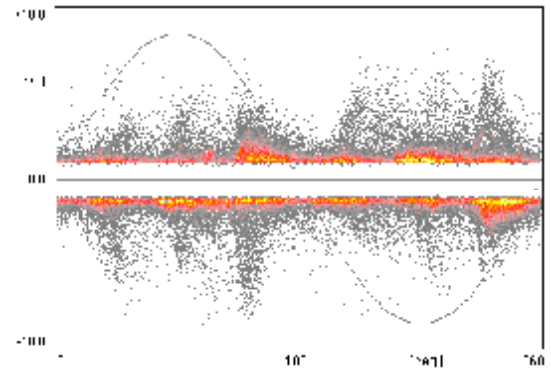
Accreditation certificate

Power Diagnostix offers in-depth support including on-site testing and installation services as well as consulting on partial discharge issues. Training sessions and seminars are offered at Power Diagnostix factory in Aachen or on-site. The DKD calibration of instruments and calibrators is offered at a competitive price.

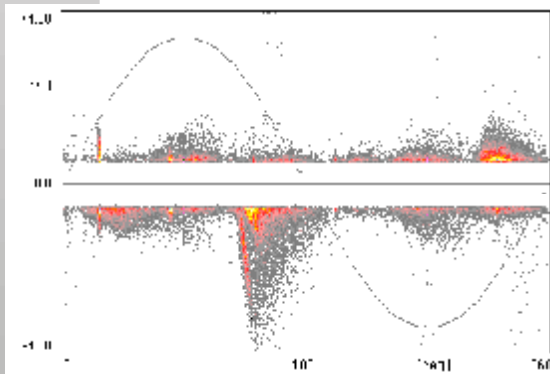
Typical PD Pattern



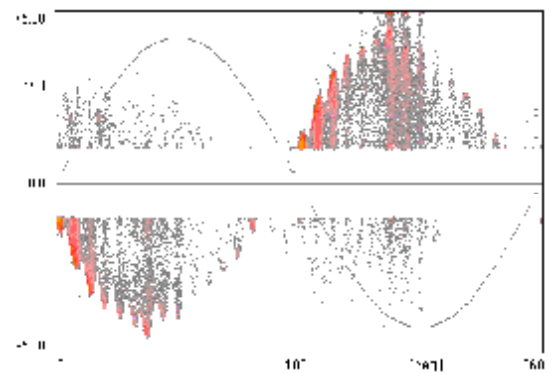
Single generator bar
Positive surface discharges for negative halfcycle in the coupling branch



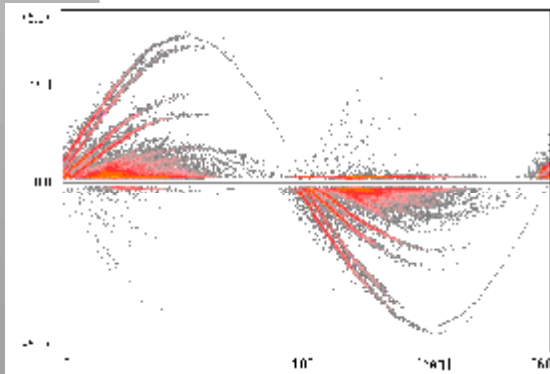
Asphalt-mica insulated hydrogenerator
Signal coupling on the neutral side
Activities for all three phases



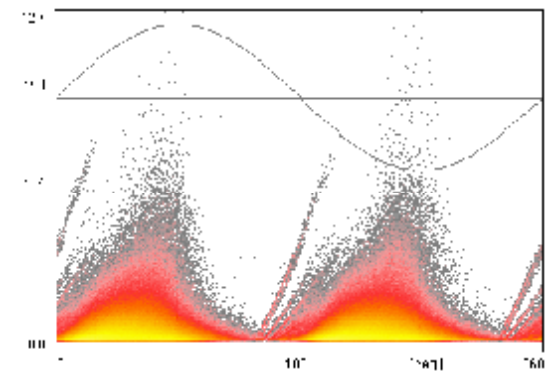
Large turbine generator
Signal coupling on the neutral side
Dominant activities for one phase



Small gas turbine generator
Line side coupling on one phase
Modulated PD pattern (33rd harmonic)

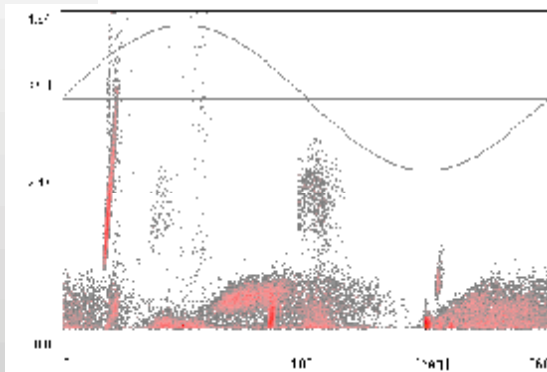


New motor coil
Several large voids

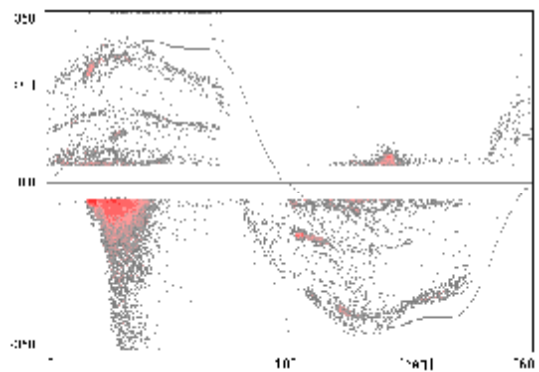


New motor coil
Strong surface discharge at the overhang
Remainder of void discharges

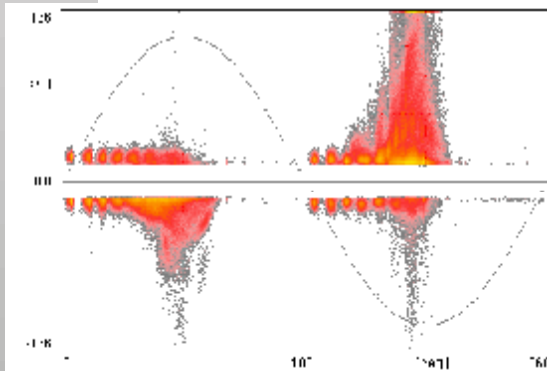
Typical PD Pattern



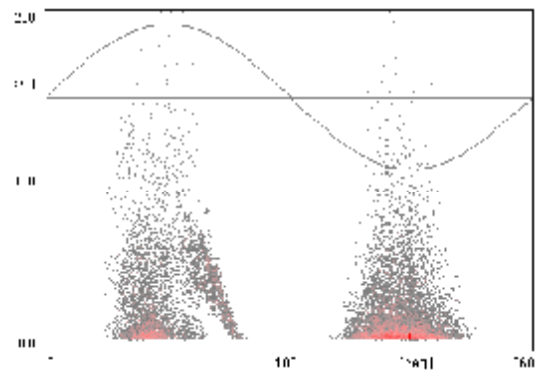
Power transformer (on-line)
Signal coupling at the bushing tap
Corona and internal discharge



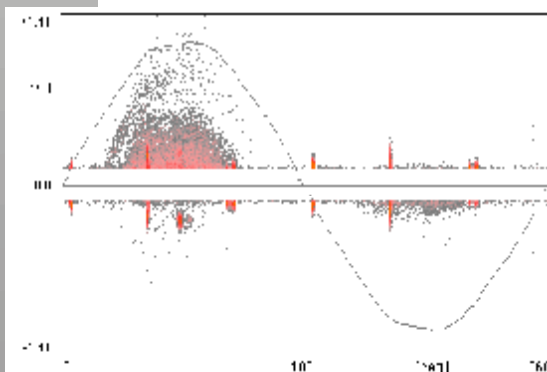
Voltage transformer
Void and surface discharge with a distorted
voltage modulating the pattern



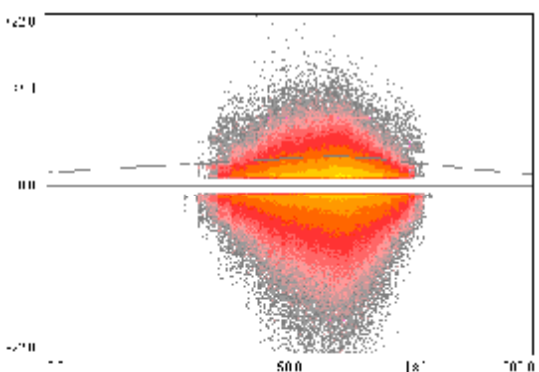
Transformer bushing
Contact problem of the field control layers



Transformer bushing
Corona discharge due to heavy rain



Transformer model
Point-plane assembly under oil

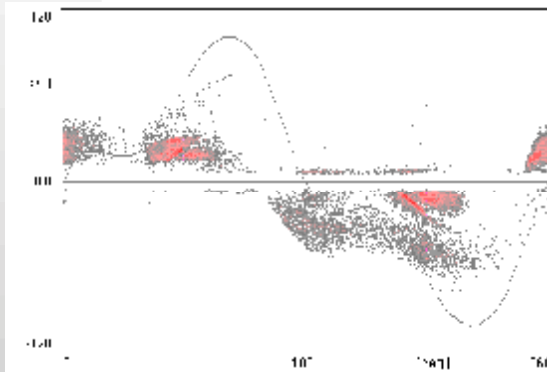


Surface discharge
Measurement versus time

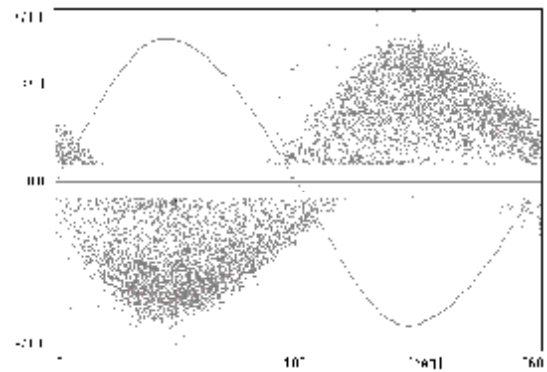
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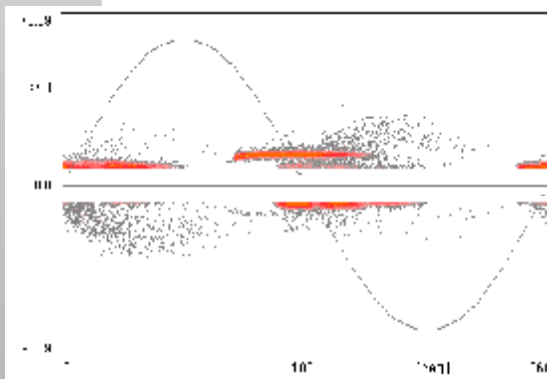
Typical PD Pattern



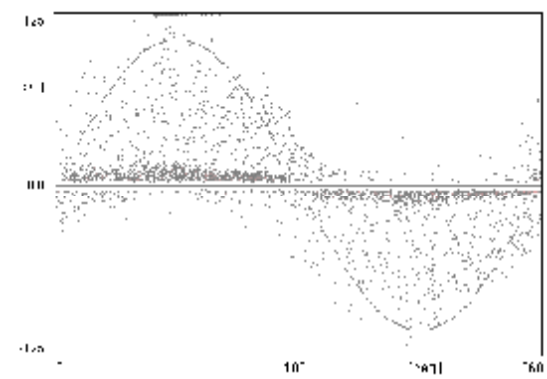
GIS instrument transformer
Excitation from the low voltage side
Influence of core saturation on the pattern



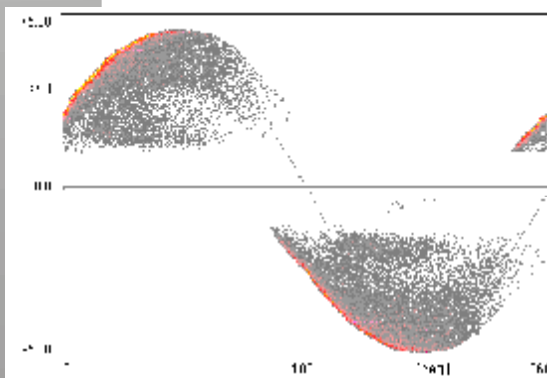
Gas-insulated switchgear
Hopping particle



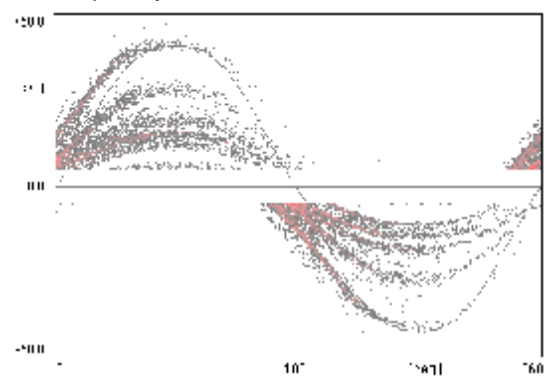
Gas-insulated switchgear
Superimposal of different PD pattern



Gas-insulated switchgear
Two hopping particles of different size and frequency of occurrence

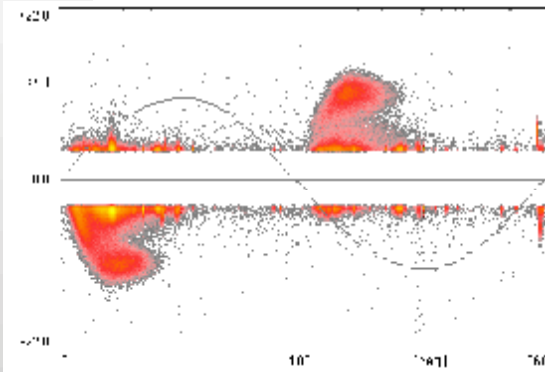


GIS isolator model
Spherical void

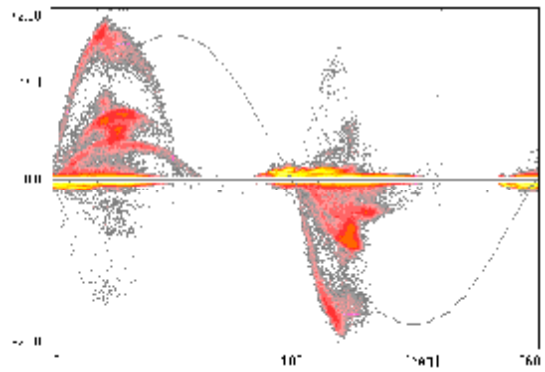


Gas-insulated switchgear
Several voids in a support insulator disc

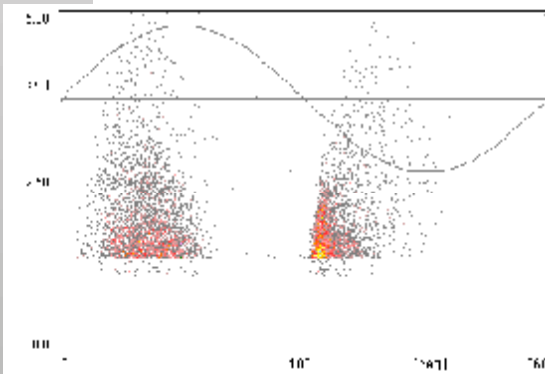
Typical PD Pattern



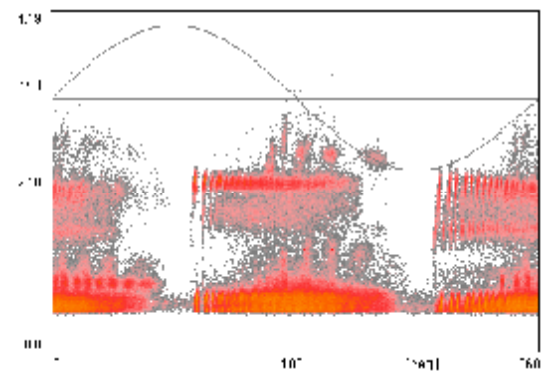
Cable joint
Internal discharges in a prefabricated EPR joint



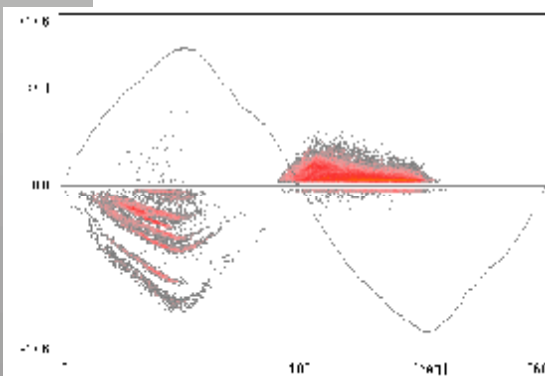
Cable termination
Several flat cavities in silicon fat due to improper mounting procedure



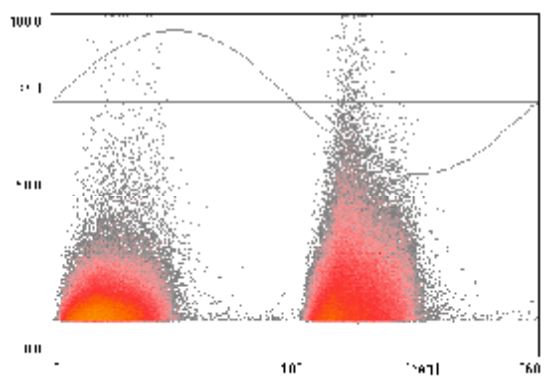
Cable joint
Discharges in a wrapped XLPE joint
Measured at 10MHz



Cable termination
Contact problem of the field control of a wrapped termination (mass impregnated)



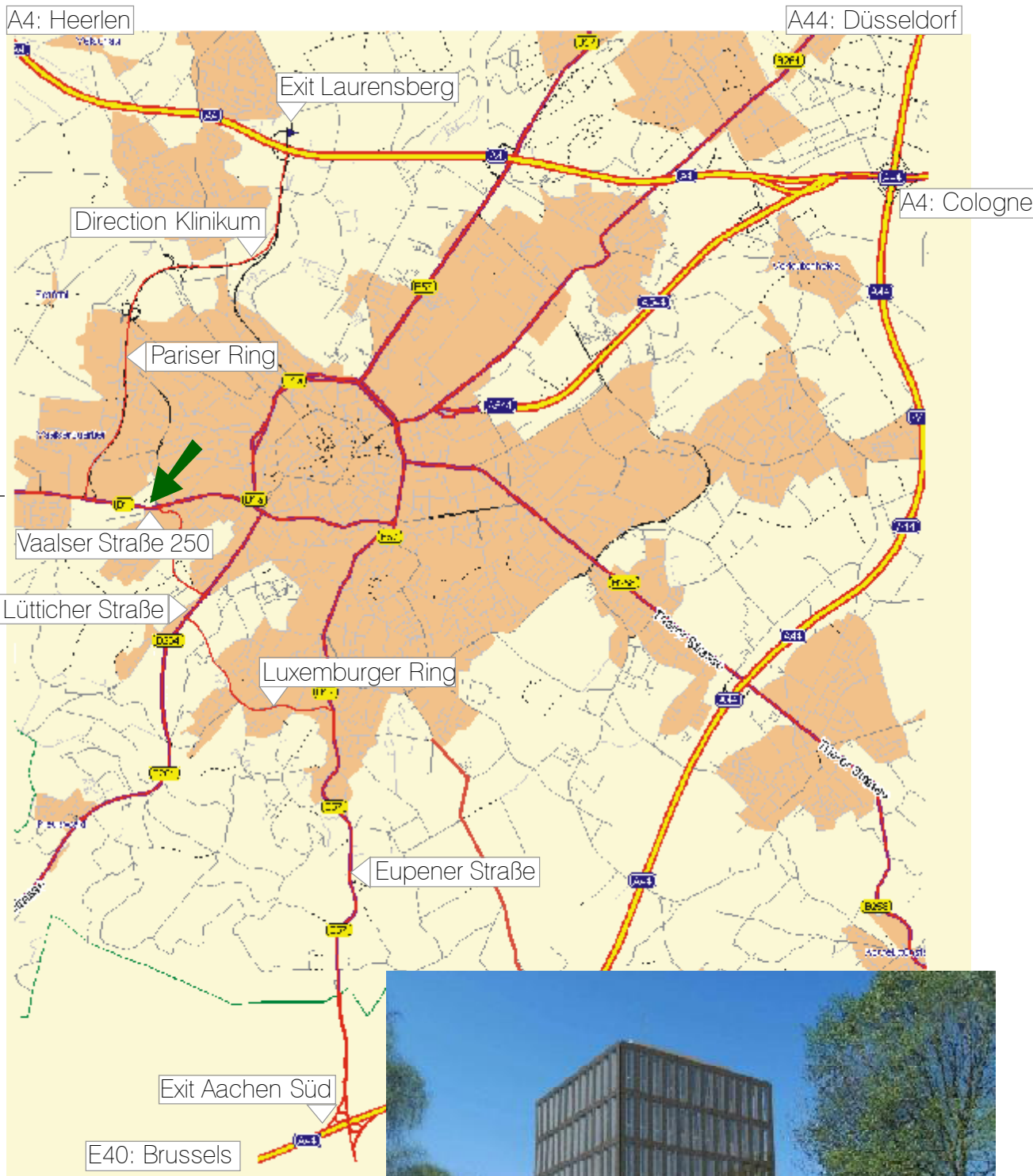
Laboratory setup
Small voids in the insulation at the interface
to a semi-conductive layer

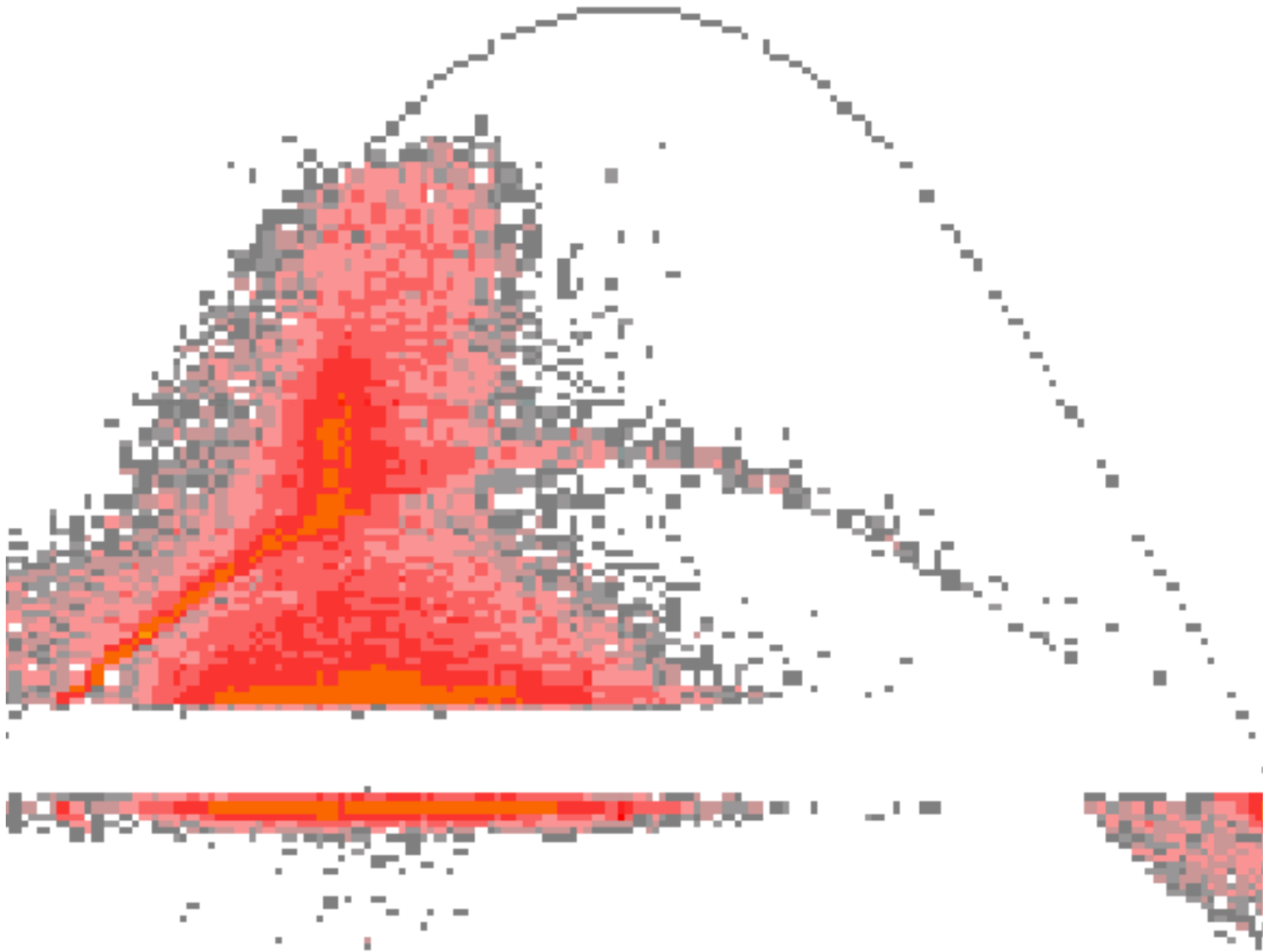


Cable joint
Delamination of the outer semi-conductive
layer of a prefabricated EPR joint

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