ICM*system*

The ICM*system* is a versatile partial discharge (PD) detector for evaluating the condition of medium and high voltage insulation. The system is fully computer controlled. All controls and displays are accessible on the control computer's screen with a graphical user interface, a so-called virtual instrument, only. The acquisition of the partial discharge pulses, as the most time critical part, is handled completely independent and asynchronous. The ICM*system* sorts the acquired partial discharge pulses with respect to the magnitude of the pulse and its phase position of occurrence into a three-dimensional pattern, whereas the color as third dimension represents the frequency of occurrence. The derived partial discharge pattern is in most cases a typical expression of the gas discharge physics of the discharging site and the involved materials. Hence, the ICM*system* is a powerful instrument for PD testing of medium and high voltage insulation.

The key to the versatility of the ICM*system* is its modular design. The ICM*system* 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. Assorted coupling devices, including quadrupoles, coupling capacitors, and current transformers, are available to sense the PD signal in the object under test. The ICM*system* provides effective noise gating that blocks phase-stable noise as well as noise independent of the applied voltage cycle, allowing the ICM*system* 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.

Rotating Machines

The typical epoxy-mica stator winding insulation system of rotating machines is a 'forgiving' insulation system. Due to its dielectric stability, partial discharge activity acts as an indicator for a variety of defect mechanisms. Besides the normal thermal aging, further problems, such as end winding contamination, bar or overhang vibrations, deterioration of grading layers, or loose wedges are common practice and can be classified by analysis of the phase resolved pattern properties.

Fig. 1: Permanent coupler installation

Capacitive couplers serve to couple to the high frequency impulse signals of the partial discharge activity occurring within rotating machines. With off-line tests the entire winding of a rotating machine is energized with a conventional high voltage test set or with a resonant test set. In case the neutral connection is opened, each of the three phases can be tested individually. Primary, secondary, and tertiary windings can be measured thanks to the ten channels of the instrument. Depending on the accessibility, a coupling to the neutral side of the winding or to the line side may be chosen.

On-line tests are usually made with line-side couplers permanently installed. The couplers, usually one coupler per phase, are mounted typically at the bus bar as close as possible to the winding. The cast aluminum box underneath the coupling capacitor contains protection circuitry against over-voltage and provides appropriate filtering of the signals. In order to avoid induced AC currents affecting the signal cables, high frequency grounding is provided with the coupler enclosure, only.

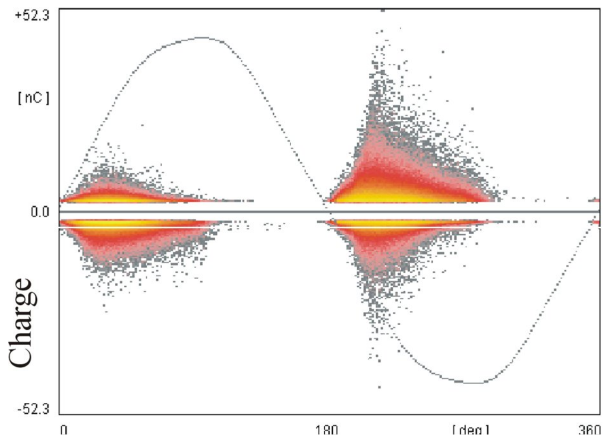

Fig. 3: Non-symmetrical discharge pattern of a heavily deteriorated slot-exit field grading.

A termination box mounted outside the machine safely ties the signal cable screens to protective ground.
When using capacitive couplers, the PD measurement bandwidth of the ICM*system* is limited to 800 kHz (AMP mode), 10 MHz (SPEC mode) or 20 MHz (AMP mode with RPA2). Higher measurement frequencies are not useful because of the signal attenuation in the test object. For instance, with 100 MHz only PD sources very close to the coupling unit can be detected.
PD measurements are in most cases hampered by noise interference originating from the excitation and control system. The ICM*system's* gating feature can be utilized to remove some of the interference signals. Especially, pulses of the excitation are promising candidates for gating.

Power and Distribution Transformers

One of the final insulation tests on a transformer in a factory test bay is the partial discharge acceptance test according to the IEC standard IEC 60076-3 (2013). This specialized test method bases on the major PD test standard IEC 60270. The multi-channel ICM*system* is specifically designed to meet

Fig. 2: ICM*system* with nine channels

the requirements of PD acceptance tests on large power transformers and greatly simplifies the test procedure. With its true parallel acquisition of the PD activity on up to ten 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. Furthermore, it offers real time parallel PD and RIV measurement on all channels.
Typically, a multi-channel ICM*system* for acceptance testing on power transformers consists of the acquisition unit and a range of accessories, such as one calibrator, preamplifiers type RPA1, and quadrupoles type CIL4M/V0µ5/2µ0. Optional accessories such as coupling capacitors up to 200 kV, different quadrupole types, or tools for noise gating, for instance, are available to adapt the system to specific needs. Additionally, the instrument can be supplied with ready-to-use installed PCs or notebook computers.
For advanced analysis an ICM*system* can be combined with a built-in or external spectrum analyzer for frequency domain analysis, a standard oscilloscope for the evaluation of the time domain signals, and accessories for acoustic measurement including triangulation software.
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.

Fig. 4: High voltage filters

In addition to laboratory tasks the ICM*system* can be used for onsite tests. Testing power or distribution in the field is a demanding task for service engineers or commissioning teams today. Such tests can be done online, means the transformer is energized and connected to the grid or offline means it is powered by a mobile power system. Due to its modular design the ICM*system* is suitable for both applications.
For UFH measurements on transformers the instrument can be used with UHF sensors such as TVS2 or TFS1, while sensors type AS75I in combination with special preamplifiers are for acoustic measurements that can be used for fault position analysis in transformer tanks.

HV and EHV Cables

Cables are generally factory-tested. The accessories of high voltage (HV) and extra high voltage (EHV) cables are usually also pretested. 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 ICM*system*, especially if combined with the FO*system* for optical isolation, offers powerful tools for the analysis of the cable insulation system.

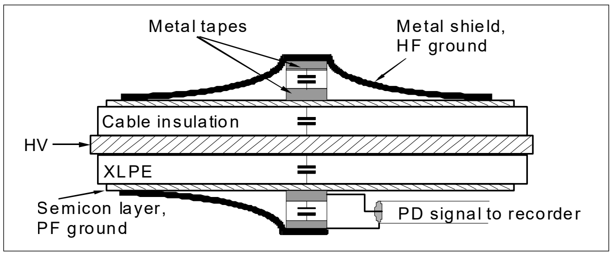

Fig. 5: Coaxial cable sensor applied to a power cable

Additionally, different pre-amplifiers and embedded or external spectrum analyzers complete the instrumentation.

Software

The ICM*system* is fully computer-controlled via communication interfaces such as LAN, the IEEE488 bus, built-in modem, USB, or fiber optic links.

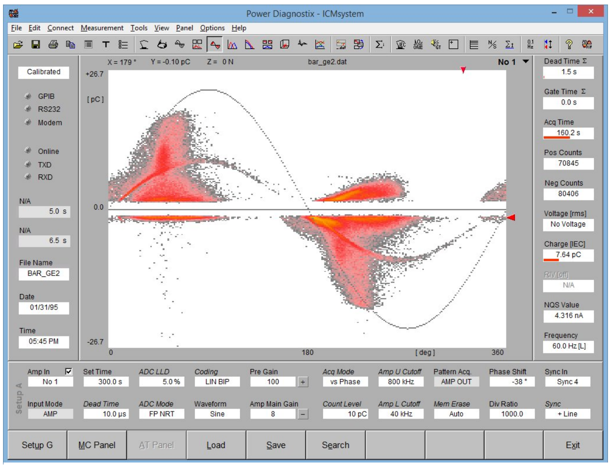

Fig. 6: Software main panel

The ICM*system* standard control software contains all functions necessary to control a 1-channel instrument, view and edit the setup parameters, acquire data, and view the results. It also contains functions to re-load, store and export acquired data. For applications such as DC testing or stepped high-voltage testing, the ICM*system* allows recording PD activity versus time (sequentially) instead of versus phase angle.
The advanced ICM*system* software version is for multi-channel systems and offers, besides all features of the standard software, semi-parallel and consecutive measurements with an ICM*system*.
The ICM*system* control software for transformer acceptance testing provides manual and automatic modes for the acceptance test.

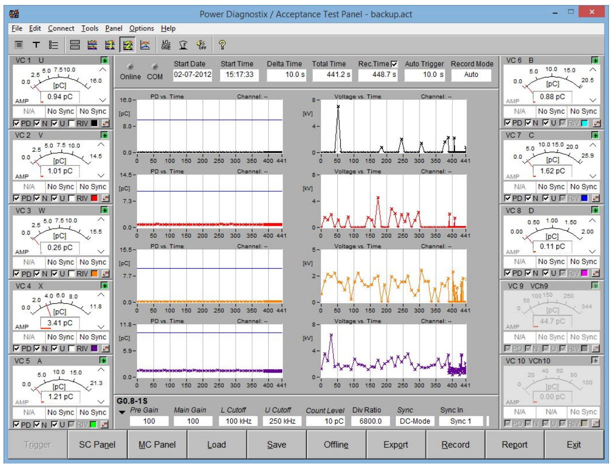

Fig. 7: Live strip chart view for acceptance tests

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

Optional Features

The optional spectrum function extends the functionality of the ICM*system* to provide a spectrum analyzer and a radio influence voltage meter for RIV measurements. Spectrum analysis is a suitable tool for electrical fault location and identifying a frequency range with a good signal to noise ration (SNR) when investigating onsite with high disturbance levels.

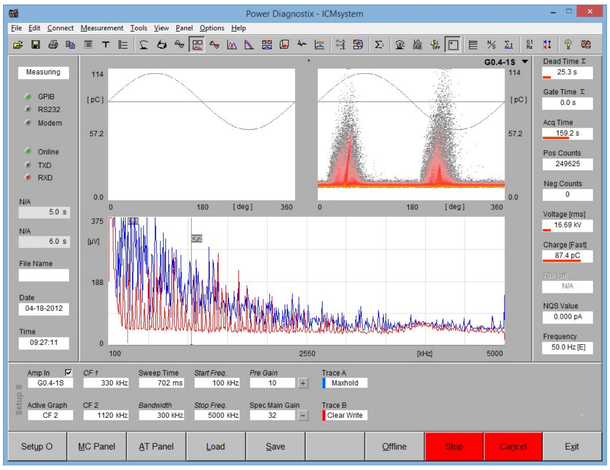

Fig. 8: SPEC panel for built-in spectrum analyzer

Another available option for the ICM*system* is cable fault location (CFL). A device with this software integrated option can perform PD fault location measurements on medium voltage cables by processing partial discharge signals by means of the time domain reflectometry.

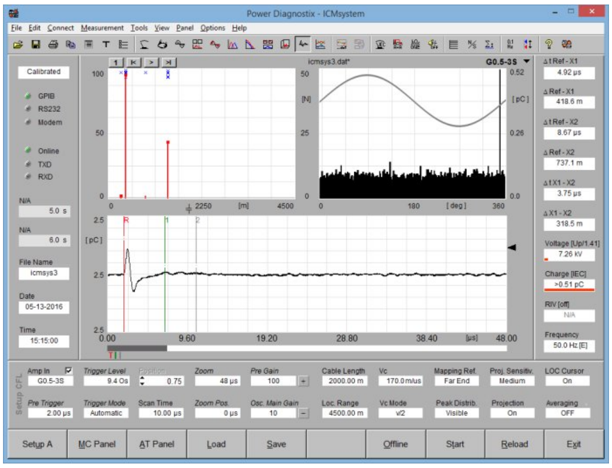

Fig. 9: Panel for cable fault location

The hardware option of a LAN interface permits remote access to data and control of the ICM*system*. Alternatively, an ICM*system* can be equipped with a modem that enables communication with the device via a conventional telephone line.

Technical Data

Acquisition Unit

Mains supply:	90–264 V_{AC}, 47–440 Hz	(automatic)
Line fuse:	2 A (time-lag)	(ICM*system* with up to 4 channels)
	3.15 A (time-lag)	(ICM*system* with 5 to 10 channels)
Power requirements:	Approx. 110 VA max.	
Operation:	Remote controlled via ICM*system* software	
Operation temperature:	0–40 °C (non-condensing)	
Input impedance (AMP IN):	50 Ω// 50 pF	
A/D converter (PD):	12 bit, compressed into 8 bit (unipolar) / ±7 bit (bipolar)	
Size:	236 x 133 x 300 mm^3	(ICM*system* with up to 4 channels)
(W x H x D, excl. BNC conn.)	450 x 133 x 300 mm^3	(ICM*system* with 5 to 10 channels)
Weight:	Approx. 6.9–9 kg	

Standard PD Mode

Lower cut-off (-6 dB):	40, 80, or 100 kHz	(software controlled)
Upper cut-off (-6 dB):	250, 600, or 800 kHz	(software controlled)
Input sensitivity:	< 500 μV_{rms} / 5pC	(without preamplifier)
Gain range:	1, 2, 4, 8, 10, 20 …, 200, 400, 800	

Preamplifier

Input impedance:	10 kΩ // 50 pF	(RPA1 / RPA1D / RPA1G / RPA4)
	1 kΩ // 50 pF	(RPA1L / RPA1H)
	50 Ω // 50 pF	(FCU2)
Input Sensitivity:	< 50 μV_{rms}/0.03 pC	(RPA1 / RPA1D / RPA1G / RPA4)
	< 15 μV_{rms}/0.02 pC	(RPA1L)
	< 40 μV_{rms}/0.05 pC	(RPA1H)
	< 800 μV_{rms}/1 pC	(RPA2)
	< 2 μV_{rms}	(RPA3)
	< 200 μV_{rms} (46 dBµV)	(FCU2)
Bandwidth:	40–800 kHz	(RPA1 / RPA1D / RPA1G / RPA4)
	40 kHz–20 MHz	(RPA1L / RPA1H)
	2–20 MHz	(RPA2)
	200 MHz–1 GHz	(RPA3)
	100 MHz–1800 MHz	(FCU2)

Synchronization / HVM

Sync. Frequency:	20–510 Hz (automatic) / 0.02–510 Hz (manual)
Maximum voltage:	200 V_{peak} (140 V_{rms}), 100 V_{rms} nom.
Input impedance:	10 MΩ
A/D converter:	±15 bit
Precision:	Typ. < 1.5%

Spectrum Function

Input sensitivity:	< 5 µV_{rms}/0.5pC	(270 kHz bandwidth)
	< 1 µV_{rms}/2pC	(9 kHz bandwidth)
Maximum input voltage:	120 mV	(300 kHz bandwidth, SPEC mode)
	5 mV	(9 kHz bandwidth, SPEC mode)
	2.5 mV	(RIV measurement)
Frequency range:	10 kHz–10 MHz (in steps of 10 kHz)	
Bandwidth:	9 kHz or 270 kHz	

Cable Fault Location

Trigger:	0 to 100% of input signal (step width in 3.125 %)
A/D Converter:	±7 bit
Samples:	100 Msamples/s (T_{sample} = 10 ns)
Reduced sample rates:	50 MS, 25 MS
Displayed time window:	200 ... 8000 samples (2 ... 80 µs @ 100 MS / 8 … 320 µs @ 25 MS)
Specimen cable length:	10 to 5000 m, for 80 µs & v_c=140 m/µs CFL at cables > 3000 m not possible because of pulse attenuation
Localization precision:	1 m + 0.1% of the cable length

Acoustic Fault Location

Trigger:	0 to 100% of input signal (step width in 3.125 %)
A/D Converter:	± 7 bit
Samples:	100 Msamples/s (T_{sample} = 10 ns)
Reduced sample rates:	50 MS, 25 MS, 10 MS, 5 MS, 1 MS
Displayed time window:	200 ... 8000 samples (2 ... 80 µs @ 100 MS / 200 … 8000 µs @ 1 MS)
Localization distance:	Max. 11.2 m, for 8000 µs & v_{oil}=1400 m/s

Available Communication Interfaces

USB 2.0

GPIB

LAN