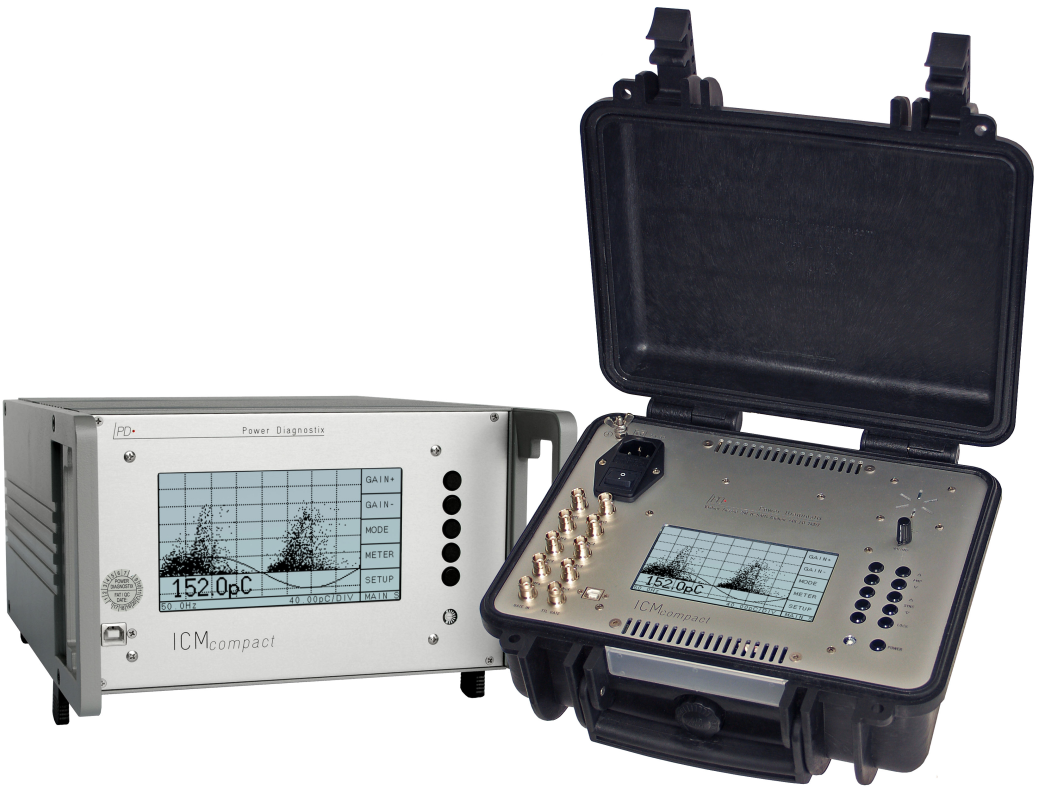
Digital Partial Discharge Detector

The ICM*compact* is a compact, stand-alone instrument for evaluating the condition of high voltage insulation. It is frequently used in factories producing high voltage equipment, such as of instrument transformers (PTs, CTs), switchgear, cables, insulators, and electronic components. Since PD testing is crucial concerning assessment of the reliability of the insulation system, also the energy providers demand partial discharge tests as part of factory acceptance tests of the HV component manufacturer's, such as testing of step-up transformers for wind farms. Thanks to its user friendly interface, and display, the ICM*compact* allows users to obtain direct results.

Fig.1 – The ICM*compact*



The ICM*compact* is Power Diagnostix' compact standard partial discharge detector. It is mainly preferred by engineers and technicians in quality control laboratories and in the fields due to its robustness and simple operation. The usage of robust RG58 cables makes it even more convenient. The ICM*compact* offers several options such as spectrum analysis, analog gating, DSO (Digital Storage Oscilloscope) for TDR (Time Domain Reflectometry) measurements, fiber optic link (COM

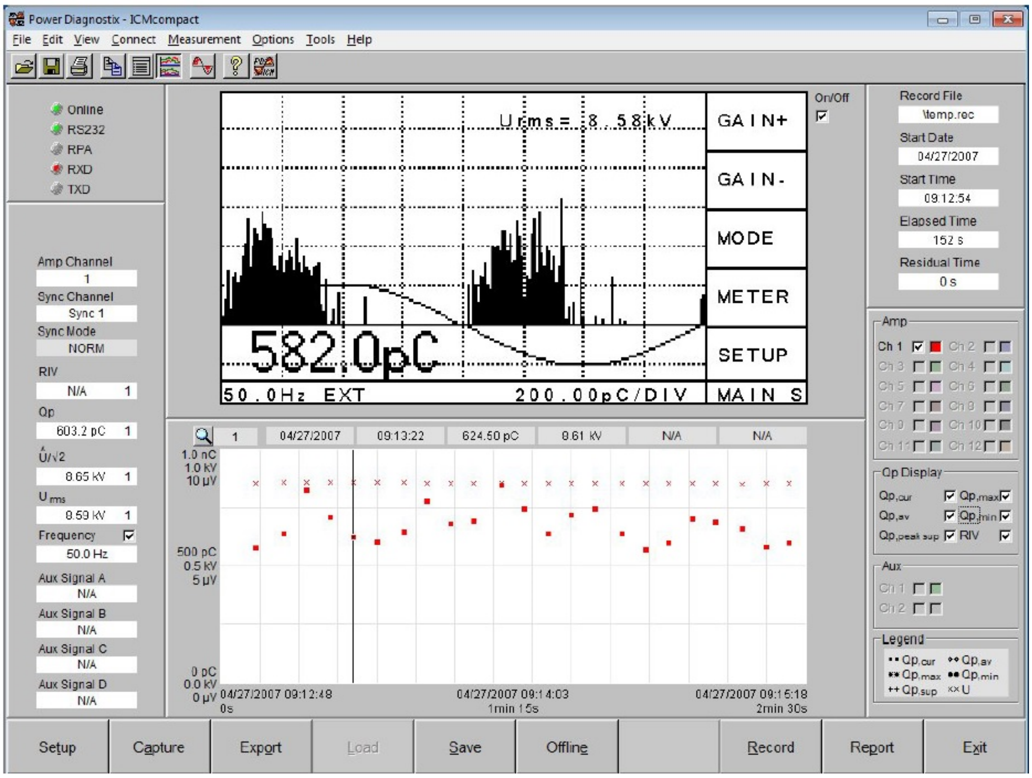
TTL), and so on. Analog gating helps to capture disturbance signals via an onboard preamplifier that is used to blind out such interfering signal. It provides communication interfaces such as USB or LAN connection. The optional fiber optic link offers a safe insulation and an extended distance between the ICM*compact* and the PC/laptop.

General Applications

The ICM*compact* is used for PD acceptance testing on HV products such as cables, instrument transformers, AIS/GIS components, isolators, bushings, stator bars & windings, electric drives, electronic components (IGBTs) and many others. Like all the PD detectors of Power Diagnostix, the ICM*compact* is also built on a modular concept. For this reason external parts such as decoupling units and preamplifiers can vary as well. The measurement circuit complies with the latest release of the IEC60270.

The standard software is also called ICM*compact*. The acquired data such as PD, voltage, AUX (auxiliary) are continuously refreshed. A remote connection can also be established by an extended fiber optic. While the PC is communicating with the instrument, it takes the acquired PD pattern and the measurement values. These acquired data can be stored and exported in different ways; so that the later analysis of the measurement is possible.

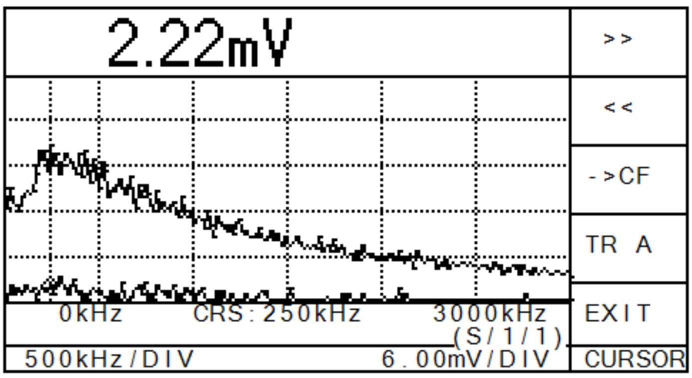
Fig.2 – The ICM*compact* Software Main Control Panel



Frequency Selective Measurements

Spectrum display of the ICM*compact* shows the frequency spectrum of the input signals up to 10MHz. Regarding the PD pattern acquisition the spectrum path offers a selection of a center frequency with a bandwidth of 9kHz or 270kHz. It is also quite useful tool allowing frequency selective measurements in noisy environments; so that the operator would be able to find out the best signal to noise ratio for the given measurement. Thus, the ICM*compact* can be used in non-shielded test room as well.

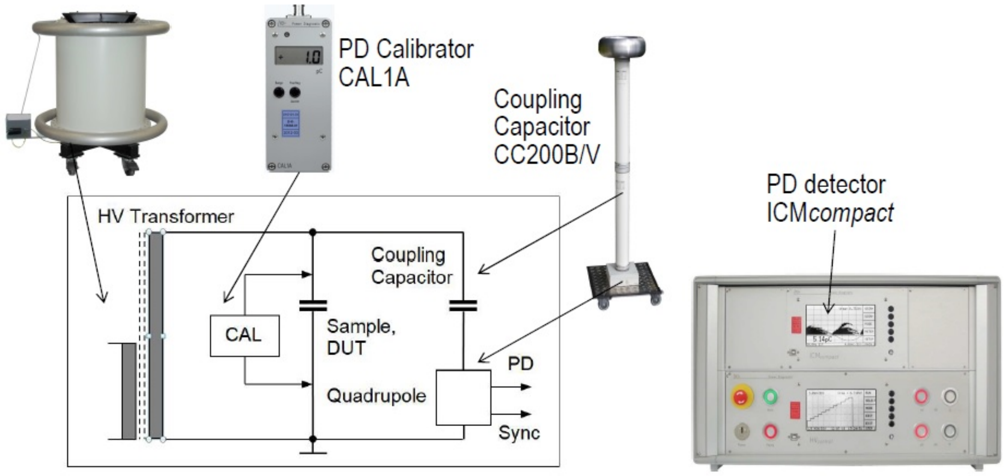
Fig. 3 – Spectrum Display



IEC60270 Compliant Laboratory Measurements

Partial discharge measurements are relative in terms of charge magnitudes and they are also not absolute measurements. That means the PD detector is calibrated in the circuit with the test object with a calibrator of known magnitude. The figure below shows the general circuit for such conventional measurements.

Fig. 4 – ICM*compact* Laboratory Measurements



Typical calibrator for conventional laboratory measurements is the type CAL1A of Power Diagnostix. It consists of step voltage generator fulfilling the amendment of IEC60270:2015. The quadrupole is placed at the earth side of the coupling capacitor. Therefore the test object can be directly connected between high voltage supply and earth. The coupling capacitor with built-in quadrupole and voltage divider senses the PD pulses and sends it as a voltage signal to a preamplifier for conditioning. The standard preamplifier of type RPA1 is connected to the AMP IN terminal with a 50 Ω coax cable, i.e. RG58. The RPA1 acts as a 50 Ω line driver and thus significantly increases overall sensitivity while working with longer cables up to 50m in a laboratory. Moreover, the RPA1 enhances the sensitivity of the coupling unit, acting to match it to the connecting cable impedance. Figure 6 also shows the high voltage control unit of type HV*control* together with the PD detector ICM*compact*. The HV*control* is used for manual or automatic operation of the high voltage transformers.

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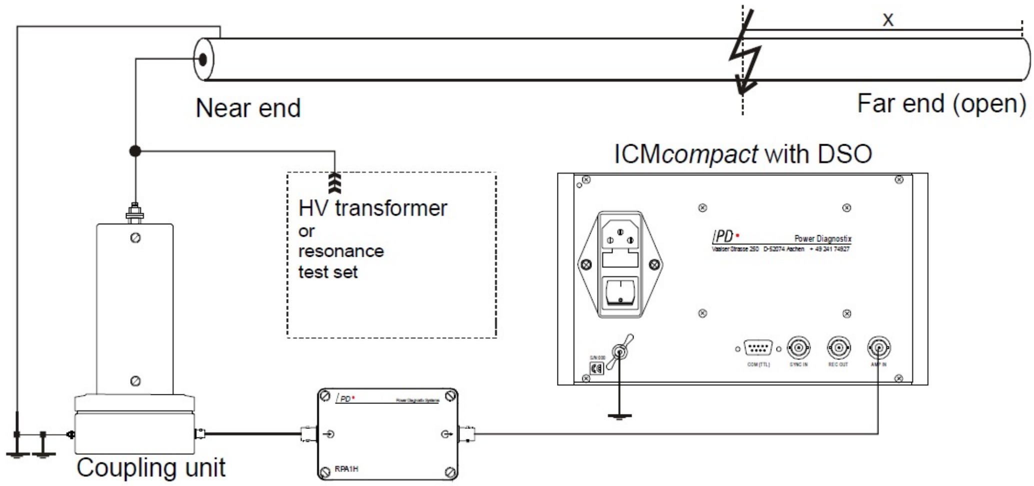
Cable Testing and Fault Location

There are several test voltage criteria and recommendation based on the baseline horizontal standard IEC60270. The below figure shows the MV cable test voltage criteria according to various IEC standards. The table shows the relevant IEC standards for medium and high voltage cables according to the cable's voltage class. The frequency, voltage and the PD criteria also differs in relation to the voltage class of the cable. Nevertheless, for the onsite cable testing generally no PD criteria is defined since the background noise can go up to the range of hundred pC, and therefore compared to the shielded test room conditions sensitivity is very critical here.

Acceptance Testing			
Standard	Frequency	Voltage	PD Criteria
1 kV < U < 40 kV			
IEC 60502	49-61 Hz	3.5 U / 5 min	1.73 U < 10 pC
	40 kV < U < 150 kV		
IEC 60840	49-61 Hz	2.5 U / 30 min	No PD up to 1.5 U
	150 kV < U < 500 kV		
IEC 62067	49-61 Hz	2.5 U / 30 min and 60 min	1.5 U < 10 pC

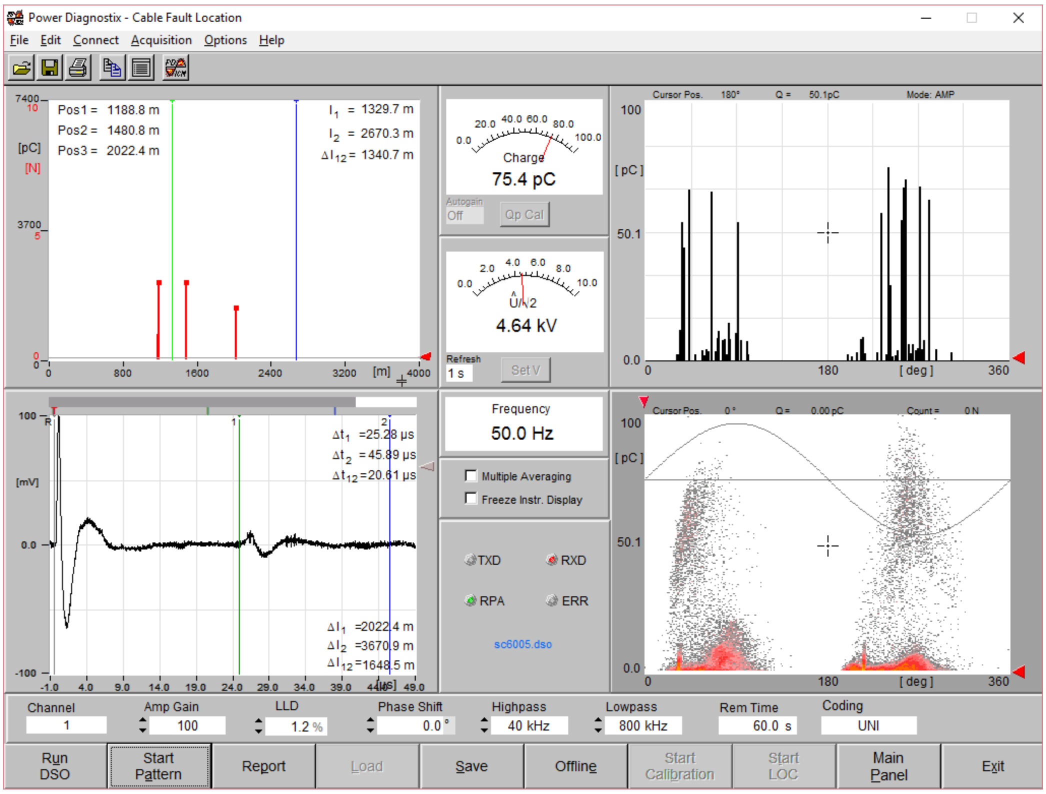
The setup for the acquisition of PD pulses in TDR has the same principle as for the PD pattern acquisition which is shown in figure 5. The device under test (cable) must have an open end, and the cable sheath must be grounded. Furthermore, it is important to note that all phases are tested separately. The PD signals are decoupled by the coupling capacitor and amplified by the preamplifier. The amplified signals are then digitized by the PD detector ICM*compact*. The calibration prior to the test should be done below 1MHz to comply with the relevant standard. The DSO board of the ICM*compact* enables TDR measurements for PD fault location on cables in production (i.e. laboratories) and on-site (online/offline). By means of the DSO acquisition board, the instrument can process and display PD signals on a time based curve. Single PD pattern can be triggered and recorded with a resolution of 10ns (100MSamples/s).

Fig. 5 – Example Setup CFL



The ICM*compact* Software with the DSO extension used to locate faults in long cables using the TDR at the cable terminations. The TDR uses the travel time of pulses. Long high voltage cables behave as a wave conductor, hence a pulse generated by a discharge travels to both cable ends. If these ends do not have the characteristic impedance of the cable, the pulse will be reflected back to the opposite end. The distance from the fault to the end of the cable is calculated from the time difference the two pulses occur at the measured end (coupling unit).

Fig. 6 - ICM*compact* CFL



The optional software extension for cable fault location feature greatly simplifies the acquisition and analysis with the DSO board.

Testing of Distribution Transformers

One of the common applications of the ICM*compact* is the testing of distribution transformers. Therefore the option Multiplexer (MUX) of the ICM*compact* is required. The figure 7 illustrates the connections of the setup for measurements on distribution transformers with an ICM*compact* with multiplexer option. In the figure the coupling capacitors of type CC100B/V with a built-in quadrupole and voltage output acts as decoupling unit and provides voltage signal for synchronization. The decoupled PD signals are amplified by preamplifiers RPA1 and then transmitted to the PD detector ICM*compact.*

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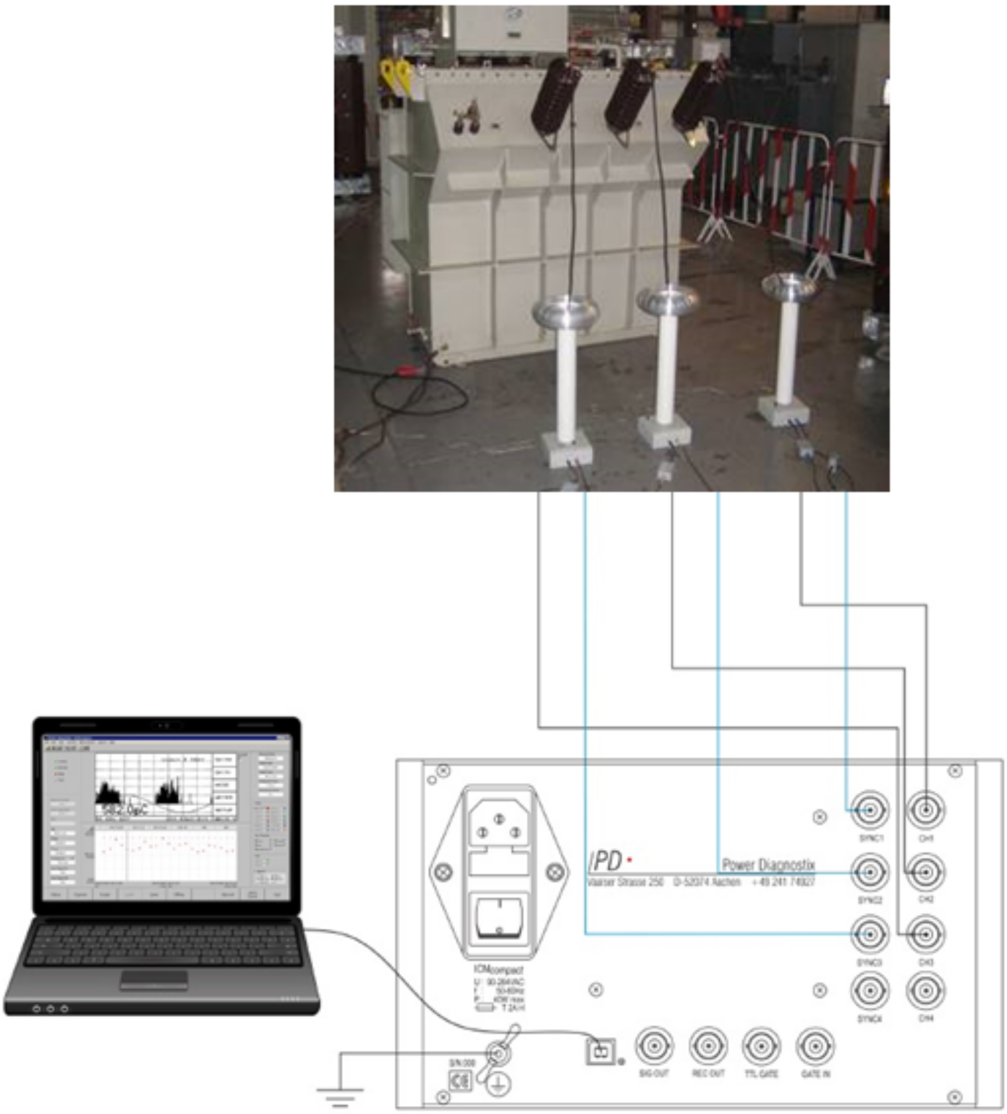
Fig. 7 – The setup for measurements on distribution transformers with the ICM*compact* with MUX option



RIV Measurements according to NEMA 107-1987 and CISPR 18-2

The ICM*compact* offers the RIV (Radio Influence Voltage) option in accordance with NEMA 107-1987 and IEC CISPR 18-2 standards. The below figure shows an example setup on a transformer bushing for the adjustment and calibration according to NEMA 107-1987.

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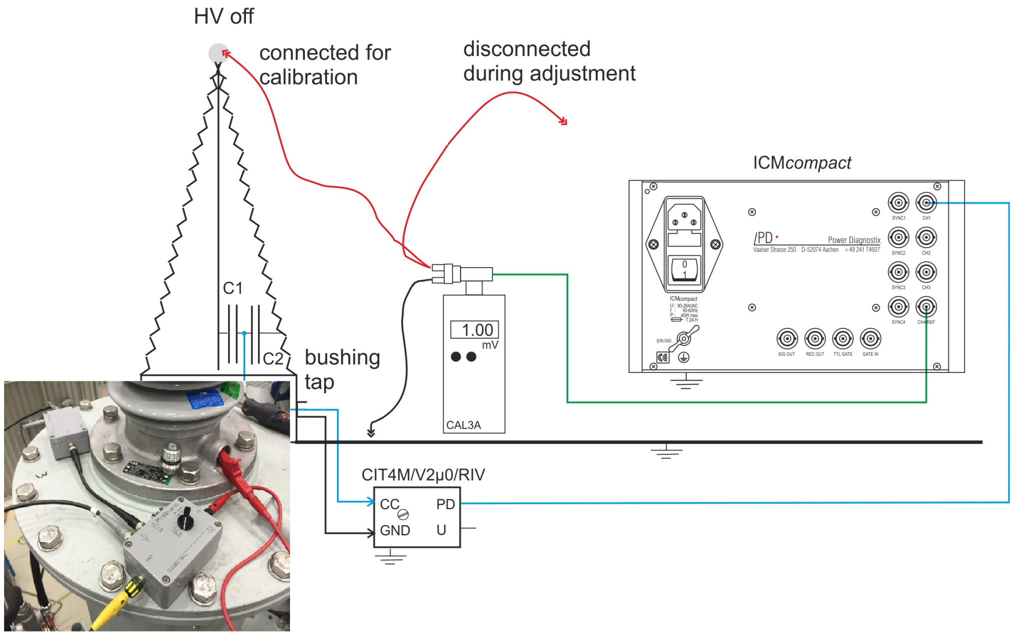
Fig. 8 – NEMA 107-1987 Compliant Calibration



The ICM*compact* is able to automatically measure, calculate and store the circuit RIV factor (k). For the calibration the HV conductor is to be disconnected and the calibrator (CAL3A or CAL3B) should be connected close to the actual RIV source.

Regarding the CISPR 18-2, the idea is that the calibrator acts a current source which causes a voltage drop of the desired calibration voltage across the specified resistor of 300Ω. This calibration principle also requires that the high voltage source is acting as RF bypass. Hence, a filter has to be inserted into the HV lead between the test object and the source.

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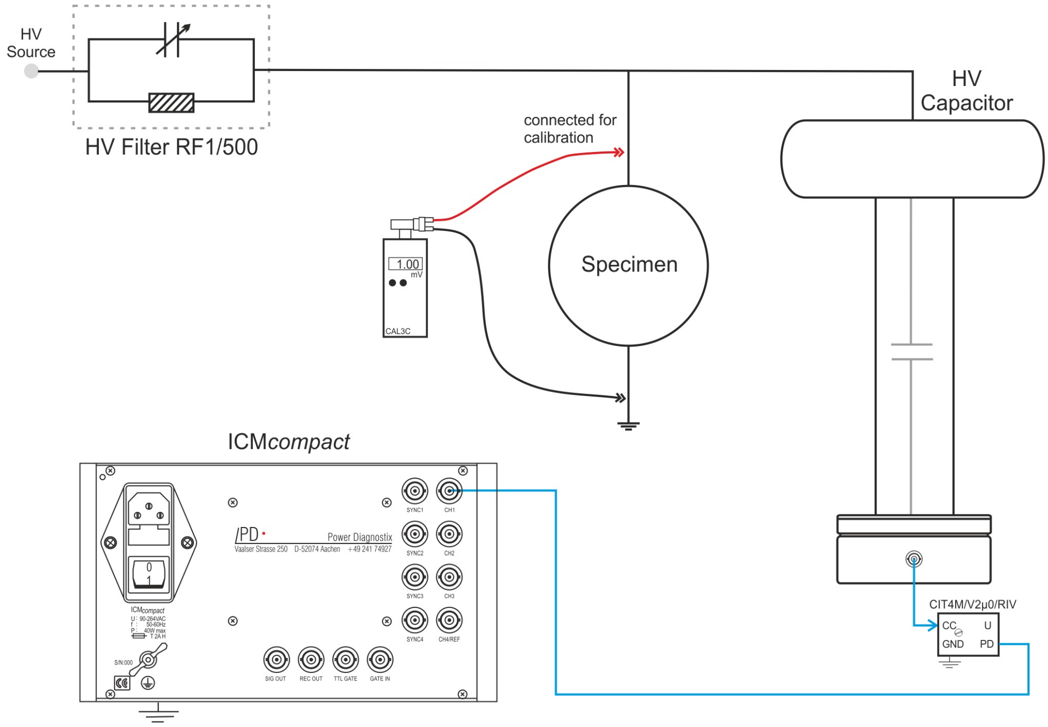
Fig. 9 – CISPR 18-2 Compliant Calibration



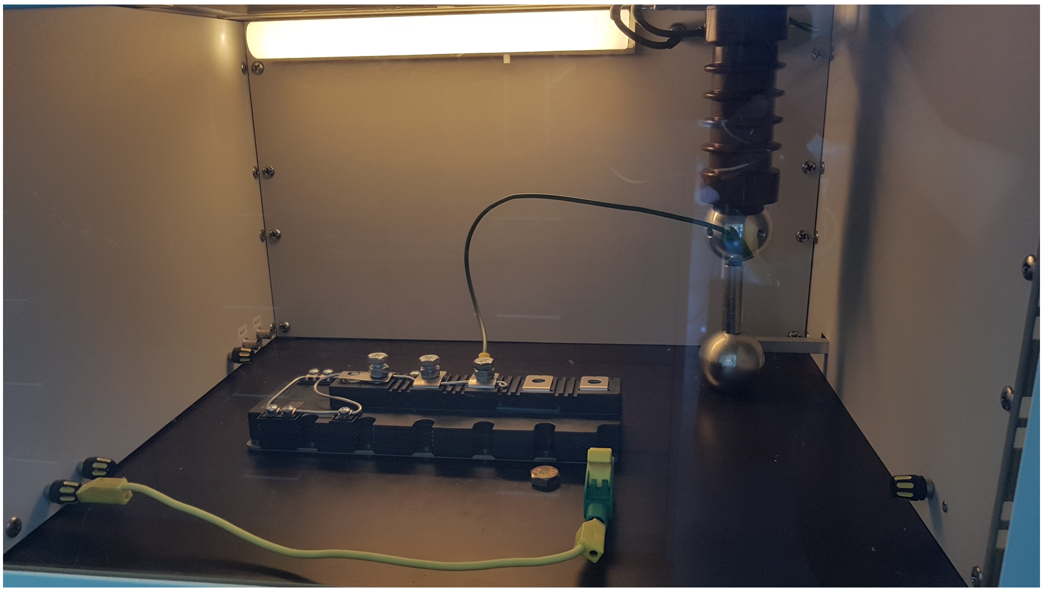
The IEC CISPR 18-2 standard specifies determining both the circuit's attenuation and the network attenuation factor in dB. This result is then added to the receiver's reading taken in dBµV, while the ICM*compact* allows the automatic calculation of the combined correction factor and displays the corrected reading after calibration.

Automatic Serial Testing for Quality Control with HV*pilot* Software

In order to integrate the ICM*compact* into a full test environment it is possible to use the HV*pilot* Software. Mostly in the factories which perform quality control of HV components, such as current transformers, voltage transformers and many more, a specialized tool in combination with ICM*compact* is preferred. The tests are carried out with respect to IEC standards e.g. IEC61869 for CTs and VTs and IEC60137 for bushings. Furthermore, the serial partial discharge testing of HV components such as IGBTs can be performed by means of a complete test system consisting of the high voltage control unit of type HV*control* and the PD detector ICM*compact*. The figure 10 illustrates the test chamber for such a test setup for an IGBT component.

PD recording can be integrated into automated setups by using Power Diagnostix' HV*control* and the HVpilot software.

Fig. 10 – IGBT testing in the test chamber



The measurement data provided by the ICM*compact* is controlled by the special software HV*pilot.* The test engineers define an automatic or manual test sequence to be able to carry out series testing. This software reads out the data from different instruments and runs high voltage test steps automatically.

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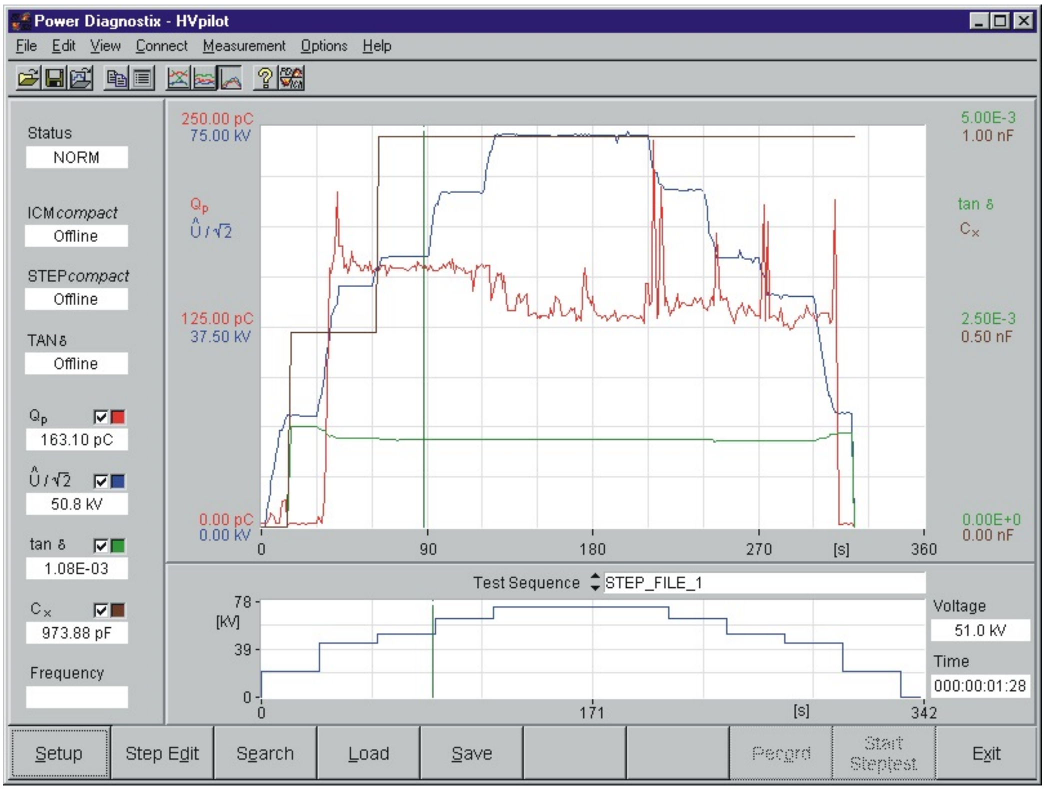
Fig. 11 – The HV*pilot* Software Main Panel



The HV*pilot* software also provides the chance to program a test sequence as well as generating a report automatically. Several test sequences can be created to customize the program for special measurement tasks. The report files are created as*.doc or *.html and can also be easily customized.

Conclusion

ICM*compact* is an excellent choice for applications such as quality control tests of electrical products and quality assurance of industrial and utility equipment. Thanks to its user-friendly interface, it is commonly used in factories of HV components for standard measurement tasks during daily work for IEC60270 compliant test setups.

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